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A PRELIMINARY TEST FOR RECORDING THE FEEDING ACTIVITY IN FISH

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A great many reports have been published on the feeding activity of various kinds of animals, especially of mammals and of insects. On fish, a number of studies have also been reported by many authors. However, they were almost all reports on feeding habits which were studied by means of examinations, evaluations and analyses of the stomach content of fishes sampled. By such methods it seems difficult to prove any correlations between feeding activity in fish and the environmental factors in either natural habitat or some experimental conditions.

Hoar[1] has reported on the feeding activity of young salmon and trout by counting the earthworm pieces or *Gammarus* sp. eaten by the fish in aquarium during a given time. Although his method is excellent as the feeding frequency could be exactly determined, yet it is not suitable when it is desired to observe fluctuations of an activity such as feeding frequency per hour over a prolonged period. A direct observation, for example, performed by Hsiao and Tester[2] seems also to be not a suitable method for the same reason, and further in this case, fish behaviour might be disturbed by the observers as they themselves have admitted. So, the present authors devised an automatic method for recording the feeding activity of fish. A simple type of apparatus and a few examples recorded by it are described below. All the experiments were performed in the tanks set in a greenhouse of the Faculty of Fisheries.

Description of the recording apparatus

A schematic view of the apparatus is presented in Fig. 1. The body of an old chemical balance was utilized as its main part. A small square cage of fine brass wire was used as a bait box (Fig. 1, A). Its size used in most cases was about $3 \times 3 \times 1$ cm. Both upper and bottom sides of the box are made of transparent celluloid. To the upper side of the box is stuck a slender and flat stalk of celluloid (B), like a peduncle, of a length of about 10 cm. The pointer of the balance (D) is cut at the portion of about its lower one third, and its cut tip is inserted solidly into a cylindrical rubber block (C). To the opposite under side of the block, the head of a large hair-pin-like holder of brass is inserted firmly. The stalk of the bait box is settled tightly by deep insertion into the holder and by winding a rubber string around the neck of the inserted portion. Both tips of the pointer and holder are inserted into the rubber block at a slight distance from each other to insulate the electric current. At each end of the balance bar, a needle of platinum (F) is settled; but, in most cases only one side was actually used. When a fish pecks the bait box, the needle vibrates and contacts with the surface of

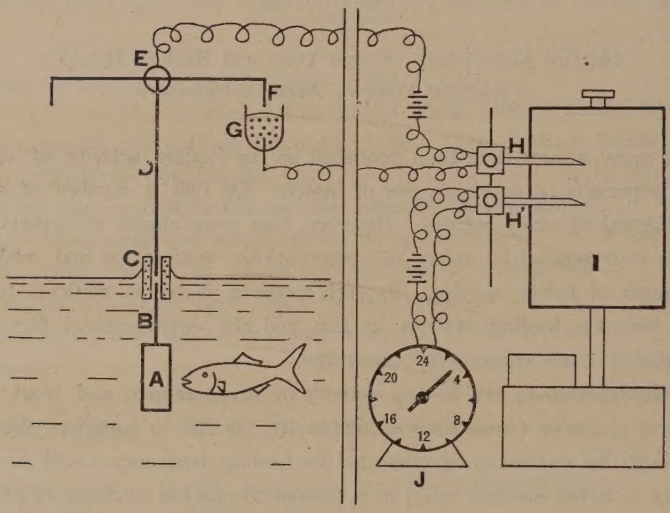

Fig. 1. A schematic view of the apparatus for recording the feeding activity in fish
A: bait box. B: stalk attached to bait box. C: insulated portion of rubber block. D: pointer of a chemical balance. E: fulcrum. F: platinum needle. G: mercury. H: electro-magnet with recording lever. H′: electro-magnet of time marker. I: kymograph. J: time marker.

mercury within the glass dish (G). Then, the circuit closes and the electro-magnet (H) with the recording lever functions as an indication of the feeding. Thus, the feeding activity of 24 hours is recorded on the kymograph (I). By preliminary experiments the distance between the tip of the platinum needle and the surface of mercury was adjusted to ensure a good contact, according to the species and body size of the experimental fishes.

From the construction of the present apparatus, it was impossible to suspend the bait box deeply in the water of the tank. In most cases, the box was hung in the water so that its bottom was at a depth of about 13 cm, the surface of the water being at about the insulated portion of the pointer.

To avoid any disturbance of the experimental fishes, some precautions were taken. For exapmle, the kymographic recordings were made in a separate room from the experimental tank at a distance of about 8 metres; the experimental tank was surrounded by a wooden wall; several straw-mats were spread on the concrete floor near the experimental tank to diminish disturbance by the noise of footsteps.

Examples of the feeding records of some fishes

All the feeding records shown in the present report were made by young fishes. Those of the three species, (A) carp, *Cyprinus carpio* (*L.*), (B) goldfish, *Carassius*

auratus (*L.*) and (C) rainbow trout, *Salmo irideus* (*G.*) are given in Fig. 2. Even from these figures only, the feeding activity and periodicity of each species may approximately be understood. Among the marks on a kymographic record may be included

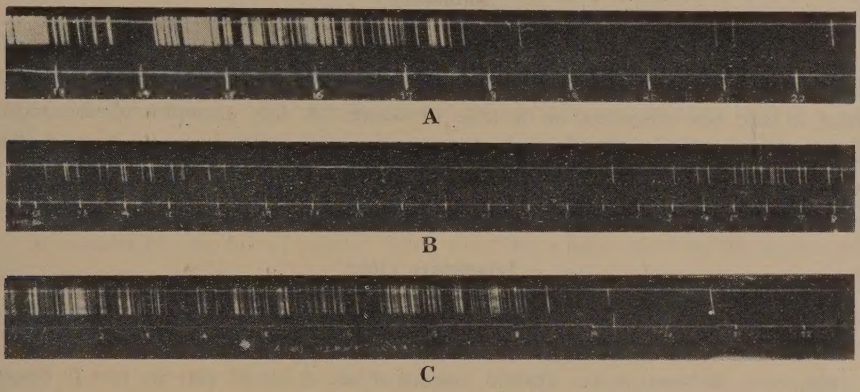

Fig. 2. Examples of kymographic records of feeding activity

A: carp, 28 individuals of 44 mm average body length; size of the tank 120 × 82 × 25 cm; bait, minced crustacean larvae; September 6, 1955. B: goldfish, 37 individuals of 40 mm average body length; size of the tank 140 × 75 × 35 cm; bait, minced crustacean larvae; September 30, 1955. C: rainbow trout, 23 individuals of 48 mm average body length; size of the tank same as the case of (B); bait, aquatic earthworms; August 20, 1955.

also some which are due to touching of a part of the fish body upon the bait box. However, even if fish does not actually peck the bait box, it may be considered that such a touch is not an accidental one, but it is a kind of feeding behaviour in a broad sense, at least, when the experimental tank is large and the fishes used are few in number.

If feeding frequency of some species is desired for a quantitative analysis, calculation may be easily done by counting the marks of its kymographic record. When the counting is difficult as the marks seem to be repeated too close together, the feeding frequency may be calculated by examining the repeated marks under a magnifier or a microscope of low power. Examples of feeding periodicity calculated by such a method are indicated in Table 1 (from the kymographic records of Fig. 2).

Table 1. Examples of the daily periodicity of feeding activity in carp, goldfish and rainbow trout, calculated from the records shown in Fig. 2

Species \ Hour	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Carp	0	0	0	0	0	1	2	19	30	37	56	19	54	45	36	14	1	0	1	1	1	0	0	0	
Goldfish	0	0	0	3	1	6	11	8	3	1	5	1	4	4	5	5	1	0	0	1	0	0	0	0	
Rainbow trout	0	0	0	0	6	11	43	30	27	42	31	46	20	8	18	31	29	34	6	1	1	0	0	0	

The present apparatus is simple and restricted in use to some experimental conditions only, the designing of some revised types of feeding recorder is in progress.

Summary

A simple method for recording the feeding activity in fish was described. The apparatus was designed to make an automatic recording on a kymograph when fish pecked a bait box suspended in a tank of water. A few examples of the records obtained were shown in Fig. 2. The feeding frequency, if desired, can be calculated from the marks of a kymographic record as indicated in Table 1. The designing of some revised types of feeding recorder is in progress.

Literature cited

1) Hoar, W. S. (1942). Diurnal variations in feeding activity of young salmon and trout. *J. Fish. Res. Bd. Canada* **6**, 90–101.

2) Hsiao, S. C. & Tester, A. L. (1955). Reaction of tuna to stimuli, 1952–53. Part II: Response of tuna to visual and visual-chemical stimuli. *U. S. Fish and Wildlife Service, Spec. Sci. Rept., Fisheries* (130), 63–76.

FISHES FROM THE NORTHERN PACIFIC AND FROM BRISTOL BAY

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Fresh-water Fisheries Research Laboratoty

Since the end of the Second World War, the Japanese Northern Pacific Salmon Fisheries has fortunately been able to resume its operation on and after 1952 in a comprehensive area extending from the northern part of the Pacific Ocean to the southern part of the Bering Sea, about 48°N, to 55°N, and 154°30′E, to 175°W, as indicated by the dotted lines in Fig. 1. The annual season runs from May to September.

A considerable number of pelagic fishes which have been taken by the salmon drift-net or hand-line come into the writers' hands for study, through the courtesy of many gentlemen. In 1952, some valuable specimens were kindly presented by Mr. I. Takeuchi of the Hokkaido Regional Fisheries Research Laboratory. In 1953 and 1954, the "Oshoro Maru", a training ship of Hokkaido University, brought many specimens taken from the Northern Pacific, during the fishing for salmon in her cruises. Here cordial thanks are expressed to Capt. S. Mishima and members of his crew. In 1954, others were kindly contributed to the ichthyological laboratory through the kindness of Messrs. T. Igarashi and T. Nakamura, inspectors of the Fisheries Agency of Japan, from the "Ginyō Maru" (a mother ship of Northern Pacific Salmon Floating Factory of the Hokkaido Fisheries Corporation), the "Miyajima Maru" (the same of the Nichiro Fisheries Company) and their catcher boats. Also, in the summer 1955, some specimens were collected by the Oceanographic Investigation in the Bering Sea by the training ship "Oshoro Maru", and

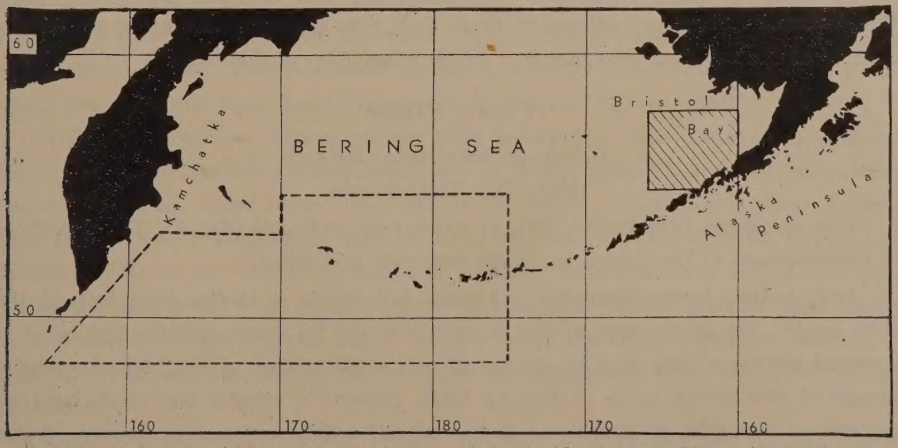

Fig. 1. Salmon and king-crab fishing grounds in the Northern Pacific and Bristol Bay
salmon fishing ground; king-crab fishing ground

added to those described in this paper.

Furthermore, the floating factory for king-crab (*Paralithodes camtschatica*) has also been re-opened after 1953 in Bristol Bay, north side of Alaska Peninsula, in the area extending over 55°N, to 58°N, and 160°W, to 166°W, as indicated by the thick line in Fig. 1.

Messrs. T. Taniwaki and M. Kawasaki of the Research Division, Fisheries Agency of Japan, then, who were on board the "Tōkei Maru" (a mother ship of the Nihon Suisan Fisheries Company for king-crab's Floating Factory) during the fishing seasons of 1953 and 1955 in the capacity of inspectors and investigators of the Japanese Government. Through their kindness many specimens of bottom fishes caught by the ground-tangle-net and bottom-trawls for crab fisheries from depths of about 50m to 200m, have come to the hands of the writers.

In 1954, Mr. S. Nakae, then a college student of this university, made a collection of bottom-fauna of Bristol Bay for purposes of investigation during his travelling on the "Oshoro Maru" and "Tōkei Maru" above noted.

Moreover, it was made possible by courtesy of Mr. K. Yamahira for the present writers to observe some specimens from Bristol Bay, which were collected by the "Tōkō Maru", an inspection vessel of the Fisheries Agency of Japan.

Therein it is proposed to make a report on observations and examinations of those fishes collected from the Northern Pacific and Bristol Bay between 1952 to 1955.

The writers express here their cordial thanks to the above mentioned gentlemen for their kindness in presentation and collection of many various specimens. Also, their indebtedness is acknowledged to Prof. R. Ishiyama of the Shimonoseki College of Fisheries, who has given painstaking instructions regarding the Rajidae of northern seas; finally heartfelt thanks are offered to Prof. S. I. Sato of this university for his various sorts of advice and kind encouragement in the prosecution of this work.

Family **Rajidae**

Breviraja parmifera (BEAN)

Nom. Jap. Tsuno-kasube

Five specimens from Bristol Bay, of which two are female (Fig. 2). The proportional measurements of the present specimens are given in Table 1.

Body is flat, having broad disc and robust tail which is shorter than half of the total length. The greater part of disc is smooth except for sparse prickles distributed in marginal portion of disc, back of the rostral region and midbelt of disc. Anterior oblique margin of disc having gentle undulating bend, presents a narrow but rough band of prickles on each side, prickles being to disperse and widely scattered posteriorly. Snout is thickened, prominently projecting, with somewhat indefinite notches on both sides. Rostral cartilage has no segment, clearly belonging to the Breviraja-type. Eye is rather

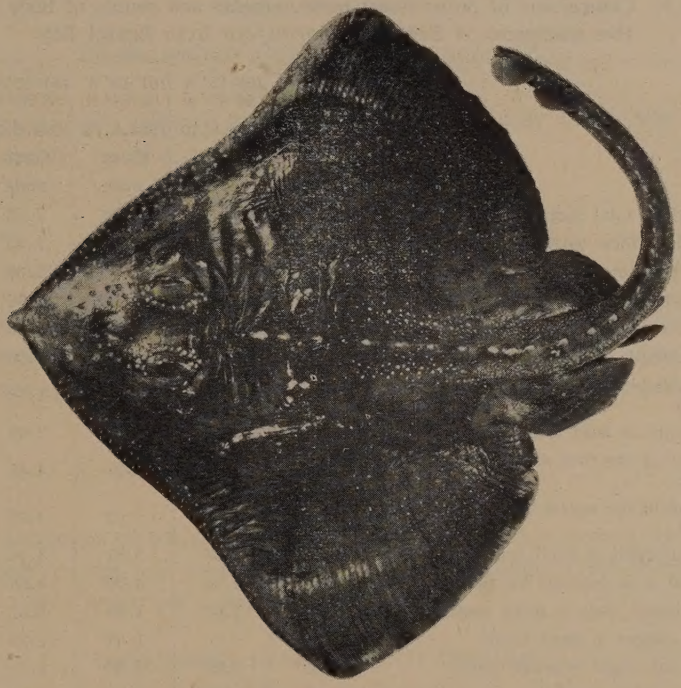

Fig. 2. *Breviraja parmifera* (BEAN), 737mm in total length (Sp. No. 13081)

large, its diameter is longer than that of spiracle. Interorbital space is broad, weakly concave, without prickles except the orbital rims, which are armed with about 10 to 12 strong, small spines. Teeth are small, arranged in oblique rows; those rows are 26 on upper jaw and 29 on lower jaw in the smallest specimen (Sp. No. 13040).

A pair of minute but distinct mucous pores present at a little behind the interorbital space, and behind that there are opposite rows of similar pores which to set as ×-shape. Three large nuchal spines form a short line on the middle of back; at a short distance from the last one, a longitudinal series of 22 to 33 large spines run along the median-line of disc and tail to the first dorsal fin, 1 or 2 spines lie between the two dorsal fins. The longitudinal series of large spines accompanying with thickly prickled band beside it, and prickles in lower lateral side of tail are denser and larger anteriorly. One or 2 large spines set on each shoulder region (three specimens with 1, the rest with 2 spines in number).

Ventral fin is of moderate size, clearly notched, dividing into two distinct lobes. The anterior lobe is thickened and finger-shape; on the contrary, the posterior lobe is flat and leaf-like. Claspers are rather short, undeveloped as perhaps the fishes are not fully

Table 1. Comparison of proportional measurements and counts of body parts in five specimens of *Breviraja parmifera* from Bristol Bay

Station	161°20′W 56°42′N	161°15′W 56°57′N	161°15′W 56°57′N	161°15′W 56°57′N	168°25′W 58°49′N
Date	1953,6,12	1954,6,10	1954,6,10	1954,6,10	1954,6,25
Sp. No.	12860	13039	13040	13041	13081
Sex	female	female	male	male	male
Disc length in total length	1.70	1.73	1.72	1.75	1.70
Disc width in total length	1.45	1.39	1.46	1.45	1.43
Tail length in total length	2.13	2.13	2.08	2.05	2.09
Head length in disc length	1.96	1.88	1.88	1.90	1.94
Snout in disc length	4.07	3.98	3.65	4.00	3.75
Precaudal length in disc length	1.54	1.54	1.57	1.50	1.58
Distance between mouth and cloaca in disc length	1.62	1.77	1.87	1.78	1.79
Preoral length in head length	1.93	1.93	1.92	2.04	1.92
Base length of the first dorsal fin in snout length	4.78	4.61	4.57	4.45	4.42
Base length of the second dorsal fin in snout length	5.79	5.30	5.02	4.45	4.79
Interorbital width in snout length	2.90	2.87	3.31	3.06	3.29
Diameter of orbit in snout length	4.78	4.08	4.00	3.63	3.59
Width of mouth cleft in snout length	1.69	1.63	1.65	1.61	1.77
Length of clasper in snout length	——	——	1.63	1.58	1.29
Width of tail origin in snout length	2.82	2.94	3.00	2.72	3.02
Number of nuchal spines	3	2-1	3	3	3
Number of shoulder spines	4	2	2	2	4
Number of spines in median row of disc and tail	26	23	33	24	22

adult. Caudal fin is small but distinct. Dermal folds along the both sides are developed, occupying about posterior one-third of the tail, and becoming broader posteriorly. As for color of specimens in formalin solution, back is uniformly dark-brown without evident blotchs and patterns; under side of disc is almost white, but some obscure dark blotches are scattered on the under surface of tail.

The scientific name of this species is here provisionally stated by the writers because the original discription was unavailable and accurate figures of this species were lacking, but it is certain that the specimens belong to Breviraja judging from the construction of rostral cartilage and other external features.

In order to make certain of the identification of this species two specimens (one female and one male) were sent to Prof. Ishiyama, an authority on the classification of northern sea rays and skates.

It will probably be made certain soon whether the specific name of this specimen is correctly applied.

Family **Clupeidae**

Clupea pallasii CUVIER & VALENCIENNES

Nom. Jap. Nishin

Two specimens were collected from Bristol Bay, their body length was 205 and 210 mm respectively (Sp. Nos. 13015, 13016).

Family **Salmonidae**

Oncorhynchus nerka (WALBAUM)

Nom. Jap. Beni-masu

The specimens were most abundantly collected among the salmon from the Northern Pacific and Bering Sea. Twenty specimens are included in the present collection (Sp. Nos. 12630, 12631, 12640, 12642–12644, 12651, 12655, 12656, 12991, 12994, and 9 other specimens).

Oncorhynchus gorbuscha (WALBAUM)

Nom. Jap. Karafuto-masu

Fourteen specimens of humpback salmon have been gathered; it seems to be abundant in the Northern Pacific and Bering Sea (Sp. Nos. 12633, 12634, 12639, 12650, 12652–12654, 12657, 12981, 12989, and 4 other specimens).

Oncorhynchus tschawytscha (WALBAUM)

Nom. Jap. Masuno-suke

Five specimens of king salmon have been added to our collection (Sp. Nos. 12632, 12648, 12988, and 2 other specimens).

Oncorhynchus keta (WALBAUM)

Nom. Jap. Sake

Thirteen specimens of dog salmon are at hand collected from the Northern Pacific and Bering Sea (Sp. Nos. 12627–12629, 12641, 12647, 12659, 12983–12985, and 4 other specimens).

Oncorhynchus kisutch (WALBAUM)

Nom. Jap. Gin-masu

It seems that the silver salmon is inferior in number as compared with other salmon of the Northern Pacific, four specimens have been received in our hands (Sp. Nos. 12646, 12996, and 2 other specimens).

Salvelinus malma (WALBAUM)

Nom. Jap. Oshoro-koma

It appears that the specimens sometimes were taken mingled with other salmon, by

the drift-net. There are six specimens in our collection (Sp. Nos. 12660, 12986, 12987, 12997, and 1 other specimen).

Family **Osmeridae**

Mallotus catervarius (PENNANT)

Nom. Jap. Karafuto-shishamo

There are sixteen specimens in the present collection, of which five are male, others are female (Sp. Nos. 13068, 13099-13113). The proportional measurements and counts of body parts are given in the following table (Table 2).

Table 2. Measurements and counts of *Mallotus catervarius* from Bristol Bay

Sex	male	female
Number of specimens	5	11
Body length in mm	115-150	82-150
Length of head in body length	4.21-4.64	4.14-4.42
Depth of body in body length	6.24-7.28	6.15-8.54
Depth of caudal peduncle in head length	3.67-4.07	4.23-4.81
Length of snout in head length	3.15-3.40	2.91-3.29
Length of maxillary in head length	2.10-2.28	2.14-2.40
Interorbital width in head length	3.98-4.46	4.21-4.82
Diameter of orbit in head length	4.02-4.39	3.49-4.31
Length of dorsal ray in head length	1.79-1.88	1.88-2.21
Length of pectoral ray in head length	1.66-1.83	1.74-2.33
Length of anal ray in head length	2.66-2.98	2.73-4.42
Length of ventral ray in head length	1.52-1.74	1.70-2.06
Number of dorsal rays	13-14	13-15
Number of pectoral rays	17-18	16-18
Number of anal rays (branched rays)	21-23(16-17)	19-22(16-18)
Number of ventral rays	8	8
Number of gill rakers on the first arch above angle	8-11	8-11
Number of gill rakers on the first arch below angle	27-29	24-30
Total number of gill rakers on the first arch	36-38	34-41

Scales are very small, cycloid. Male has two villous bands along each side of body.

Family **Anotopteridae**

Anotopterus pharao ZUGMAYER

Nom. Jap. Mizu-uwo-damashi

A single specimen, measuring 876mm in total length and 817mm in body length, was added to our collection (Sp. No. 12976). The present specimen was taken by salmon drift-net of the "Rinkō Maru" of a catcher boat belonging to the fleet of the "Ginyō Maru", at 49°45′N, 170°25′E, on June 8, 1954 (Fig. 3).

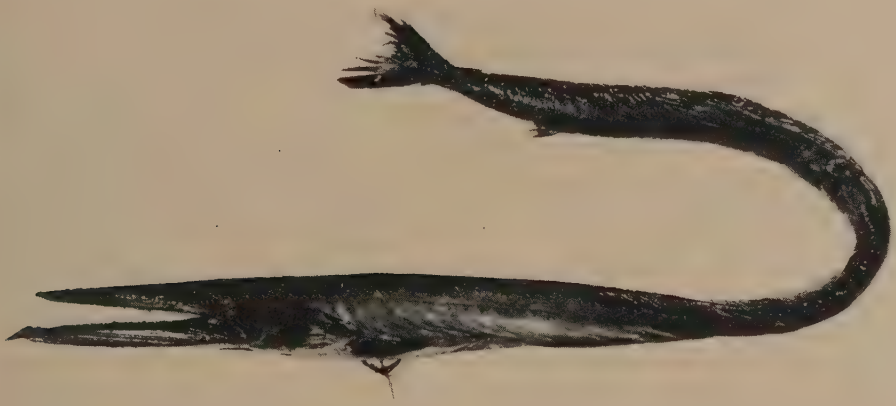

Fig. 3. *Anotopterus pharao* ZUGMAYER, 876mm in total length (Sp. No. 12976)

Table 3. Measurements of body part of *Anotopterus pharao* are expressed in ratio to body length (B. L.) and head length (H. L.).

Items	Measurement (mm)	Ratio to B. L.
Length of head	194	4.20
Depth of body	52	15.69
Length of snout	110	7.41
Length of premaxil'ary	133	6.13
Length of lower jaw	146	5.58
Distance from tip of snout to adipose fin	735	1.11
Distance from tip of lower jaw to base of pectoral fin	201	4.06
Distance between pectoral fin to ventral fin	278	2.83
Distance between ventral fin to anal fin	222	3.67
Distance from tip of lower jaw to anal fin	524	1.56
		Ratio to H. L.
Greatest width of head	20	9.70
Length of snout	110	1.76
Length of premaxillary	133	1.46
Length of lower jaw	146	1.33
Diameter of orbit	18	10.77
Diameter of pupil	5	34.80
Length of caudal peduncle (from the last of anal fin to origin of caudal fin)	59	3.29
Depth of caudal peduncle	14	13.85
Postorbital part of head	70	2.77
Base length of pectoral fin	18	10.77
Base length of anal fin	53	3.66
Base length of ventral fin	13	14.91

A. 17; P. 13 on each side; V. 10 on the left, 9 on the right side; C. xiii–18–xiii; Branchiostegals 7 on each side; Gill rakers are entirely lacking; Gills are 4 in number.

Palatine teeth are very remarkable, blade-shaped or lancet-like, arranged in a row on each palatine, anterior two on each side are fixed, the third and fourth of each side are the largest among the palatine teeth, and those of left side are fixed, but those of right side are movable, the posterior-most ones on each side are shorter, and movable. The teeth on lower jaw are small, but are sharply pointed, numbering 16 on right side and 13 on left side. Premaxillary teeth are minute, arranged in a single row. The lateral pores are 83 on the right side and 82 on the left, in number, forming pairs of blackish pores; they run as close-set parallel lines from the occipital region to the base of caudal fin along the median line of body. Additionally, it is noteworthy that the present specimen has thin, caducous cycloid scales chiefly scattered in a lateral line on under part of body.

The upper lobe of the first gill arch on each side is connected with the inside of opercular bone by a thin membrane, and gill rakers are lacking on both lobes. Measurements of this specimen are presented in Table 3.

Family **Alepisauridae**

Alepisaurus ferox (*LOWE*)

Nom. Jap. Mizu-uwo

Nine specimens were taken by salmon drift-net from the Northern Pacific in 1953 and 1954 (Sp. Nos. 12311–12313, 12661, 12662, 12972–12975) (Fig. 4).

Fig. 4. *Alepisaurus ferox* (*LOWE*), 1124mm in total length (Sp. No. 12311)

Table 4. Measurements and counts of *Alepisaurus ferox*

Items	No.	Range
Total length in mm	9	640–1365
Body length in mm	9	580–1220
Length of head in body length	9	5.09–5.72
Greatest depth of body in body length (at origin of dorsal fin)	9	10.00–12.24
Base length of dorsal fin in body length	9	1.55–1.69
Base length of anal fin in body length	9	8.24–10.58
Distance between tip of snout and origin of dorsal fin in body length	9	5.20–5.85
Distance between pectoral fin and ventral fin in body length	9	3.63–4.45
Distance between ventral fin and anal fin in body length	9	3.04–3.54
Distance between dorsal fin and adipose fin in body length	9	16.76–19.56
Longest ray of dorsal fin in body length	6	4.04–5.22
Longest ray of pectoral fin in body length	9	4.72–6.54
Longest ray of anal fin in body length	5	15.28–17.76
Longest ray of ventral fin in body length	5	11.43–14.35
Longest ray of caudal fin in body length	5	6.14–7.62
Length of snout in head length	9	2.33–2.74
Greatest width of head in head length (at anterior part of opercular bone)	9	3.67–4.19
Length of premaxillary in head length	9	1.32–1.42
Length of lower jaw in head length	9	1.35–1.42
Width of mouth cleft in head length	5	6.66–7.60
Diameter of orbit in head length	8	5.13–6.22
Diameter of pupil in head length	7	18.00–19.55
Least width of interorbital space in head length	9	5.26–6.53
Least depth of caudal peduncle in head length	9	6.60–7.65
Length of caudal peduncle in head length (from the last ray of anal ray to origin of caudal fin)	9	2.05–2.64
Length of postorbital part of head in head length	9	2.24–2.47
Base length of pectoral fin in head length	9	5.08–6.94
Base length of ventral fin in head length	6	10.13–11.85
Number of dorsal fin rays	9	35–38
Number of anal fin rays	9	15–17
Number of pectoral fin rays on each side (left:right)	9	13–14:13–14
Number of ventral fin rays on each side (left:right)	9	9:9
Number of gill rakers on the first arch	8	4–6+18–23
Number of vertebrae	3	48

The above table (Table 4) indicates range of relative ratios our specimens of *Alepisaurus ferox*.

Premaxillary teeth are very small, more than 70 in number on each side, arranged in a single row, and each premaxillary bone is not united at anterior tip. Number and arrangement of teeth on lower jaw and palatine are conspicuously variant not only between

individuals but also on both sides of one individual. Some teeth on lower jaw and palatines are strikingly elongated and become sharp canine teeth, and also, some anterior ones are movable but posterior ones are all immovable, triangular in shape. The first ray of dorsal, anal and pectoral are thickened, and armed with minute serrations on their outer margins.

Family **Acrotidae**

Acrotus willoughbyi BEAN

Seven specimens of this peculiar fish have been obtained through the courtesy of Mr. T. Igarashi. The specimens were taken from the sea near 49°N, 170°E, at the middle of June, 1954 (Sp. Nos. 12965–12971) (Fig. 5).

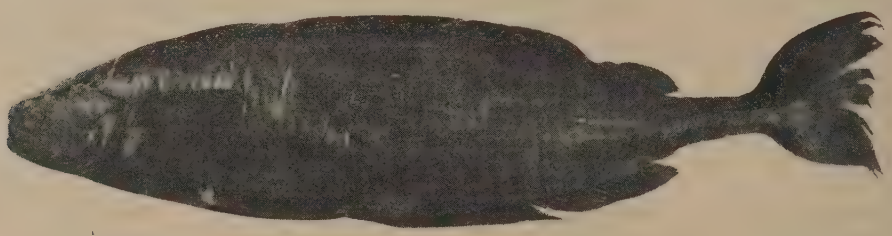

Fig. 5. *Acrotus willoughbyi* BEAN, 686mm in total length (Sp. No. 12967)

Body length measures 478 to 745mm; body is elongate, elliptical, and greatly compressed. No scales on body so, body is very smooth and limp. Caudal fin is very broad, fan-like, and continues as a very slender caudal peduncle. Pelvic fins are entirely absent. Lateral line is slightly arched above the pectoral fin, henceforth, it runs straight along the median of body backward to caudal fin base. Small spinous processes are found on the lateral line.

D. 50–55; A. 33–39; P. 18–21; C. 27–33; B. 7 (on each side)

Head 4.71–5.47 in body length; depth of body 3.52–4.59. Snout 2.90–3.54 in head length; maxillary 2.29–2.97; interorbital width 2.16–2.66; diameter of orbit 6.33–8.46; depth of caudal peduncle 3.73–4.97; the longest ray of dorsal fin 3.10–3.69; the same of pectoral fin 1.50–1.81; the same of anal fin 2.78–3.41. Length of dorsal fin base 1.47–1.65 in body length; the same of anal fin 2.40–2.78; distance between tip of snout and vent 2.27–2.85. Gill rakers on the first arch are 5–7+9–10 in number. Vertebrae are 70 in number in one specimen. Color is chocolate brown uniformly, mouth-cavity and inside of gill opening are blackish dark brown.

There are some distinctions in which there are differences from other past references, namely, depth of body is shorter, length of snout, diameter of orbit, and interorbital width etc. are longer, and also, number of dorsal rays and branchiostegal rays are more

compared to the description until now.

Family **Hexagrammidae**

Pleurogrammus monopterygius (PALLAS)

Nom. Jap. Kitano-hokke

Seven specimens had been taken by salmon drift-net from the Bering Sea in 1955, measuring 208–261mm in body length (Sp. Nos. 14248-14253, and one other specimen).

D. 47–49; A. 24–27; P. 23–25

Head 3.96 4.24 in body length; depth of body 4.34–4.98. Snout 2.98–3.17 in head length; maxillary 2.66–2.78; interorbital width 2.98–3.20; diameter of orbit 4.70 5.59; depth of caudal peduncle 4.00–4.20; the longest ray of ventral fin 1.93–2.08. Number of gill rakers are $\frac{2-3+12-15}{7-8+18-19}$ on the first gill arch from four specimens.

The third lateral line reaches to 16th or 20th ray on the left side, and 15th or 20th on the right side. The lateral pores are 139–149 on the second lateral line, but one specimen has 160 pores.

Color, greenish dark blue, and almost always seven darkish stripes appear on the body side.

This species is very nearly related to *P. azonus*, but differs from it in respect to total number of dorsal and anal fin rays, and second lateral line scales are less than *P. azonus* in number.

Family **Cottidae**

Icelus uncinalis GILBERT & BURKE

Nom. Jap. Hime-kori-kajika

Two specimens were collected from Bristol Bay, measuring 84 and 88mm in body length (Sp. Nos. 13019, 13022).

D. IX–X, 19–21; A. 16–18; P. 18–19; V. I, 3

Head 2.70–2.76 in body length; depth of body 4.66–4.89. Snout 3.44–3.45 in head length; maxillary 1.85–1.88; depth of caudal peduncle 7.75–7.95; interorbital width 15.5–15.9; diameter of orbit 3.22–3.24; length of eye 3.52–3.65; length of longest dorsal spine 3.10–3.31; longest dorsal ray 2.48–2.54; pectoral ray 1.32–1.37; anal ray 3.03–3.18. Number of plates on lateral line 41–42, and under the dorsal fin series 33–37. Small verrucacae are found on the upper eye bole. Preopercular spines 4, the upper one is branched, nasal spines and those on each side of nape are very sharp. Lacks cross-folds on the breast, hole on posterior last gill arch, and gill rakers fused. Interorbital space narrow and rain pipe like. Teeth on vomer and palatines.

Triglops beani GILBERT

Nom. Jap. Hokkyoku-kajika

Five specimens were collected from Bristol Bay (one specimen was damaged), measuring 116–184mm in body length (Sp. Nos. 13020, 13021, 13023–13025).

D. X–XI, 24–26; A. 23–25; P. 17–19; V. I, 3

Head 3.45–3.57 in body length; depth of body 6.30–7.30. Snout 3.03–3.20 in head length; maxillary 2.09–2.24; depth of caudal peduncle 7.93–8.69; diameter of orbit 3.49–3.71; length of eye 3.61–4.32. Interorbital width 2.80–3.31 in diameter of orbit. Not forming high orbital rims. Eyes small, their diameter smaller than length of snout. Length of longest dorsal spine 2.54–3.38 in head length; longest dorsal ray 2.68–2.94; longest pectoral ray 1.29–1.42; longest anal ray 2.99–3.14. Number of scales along lateral line 48–51, and plates under dorsal 26–35; gill rakers on the first gill arch above angle $\frac{1-2}{0}$, belw angle $\frac{8-9}{5-7}$; preopercular spines 4. Cross-folds on the breast.

Hemilepidotus gilberti JORDAN & STARKS

Nom. Jap. Yokosuji-kajika

One specimen collected from Bristol Bay, measuring 179mm in body length (Sp. No. 13027).

D. XI, 22; P. 18; A. 18; V. I, 4

Head 2.82 in body length; depth of body 3.95. Snout 3.30 in head length; maxillary 2.26; depth of caudal peduncle 5.37; diameter of orbit 3.50; length of eye 4.14; first dorsal spine 3.30; third dorsal spine 3.20; fourth dorsal spine 2.75: third dorsal ray 2.12: fifth pectoral ray 1.42; fourth anal ray 2.94; middle caudal ray 1.58. Interorbital width 1.28 in eye. Number of scales on lateral line 67, scales of under dorsal fin 72 and wart-like scales in single line on upper series of anal fin, they are very obscure. Number of gill rakers $\frac{0+8}{2+6}$ on the first gill arch; preopercular spines 4.

Filaments: large single one on the maxillary, small branched filaments on the orbital and on each side of nape, and large branched one on the upper base of opercle.

Myoxocephalus polyacanthocephalus (PALLAS)

Nom. Jap. Toge-kajika

Ten specimens were collected from Bristol Bay, measuring 296–630mm in body length (Sp. Nos 12861–12864, 13031–13035, 13038).

D. IX–X, 14–15; A. 12–13; P. 18–19; V. I, 3

Head 2.22–2.39 in body length; depth of body 3.70–4.95. Snout 2.87–3.40 in head length; maxillary 1.75–1.96; depth ef caudal peduncle 6.42–7.23; interorbital width 5.70–7.21; diameter of orbit 5.18–6.07; length of eye 7.50–10.01; depth of head 1.76–2.54; length of third dorsal spine 2.47–3.29; fifth dorsal ray 2.27–2.69; longest pectoral ray 1.70–1.90; longest anal ray 2.88–3.88; longest ventral ray 2.38–3.11; middle caudal ray 2.26–2.70. Preopercular spines number three or four; length of upper preopercular spine

5.00 8.38 in head length, and distance from tip of upper preopercular spine to tip of opercle 4.19–6.20 in head length.

The postorbital spine is rather conspicuous. Teeth on vomer, but palatines toothless. Number of pores on lateral line 38–43, sometimes lateral line is not clear. Small rounded warts scatter on the upper and lower lateral line, sometimes they are not clear. In one specimen there is a clear one under the first dorsal fin, however obscure in the other specimens. Number of gill rakers $\frac{1+6-11}{0-1+6-7}$ on the first gill arch.

Color, bright brown, several clear white spots occur on the body sides.

Myoxocephalus jaok (CUVIER & VALENCIENNES)

Nom. Jap. Oku-kajika

Only two specimens collected from Bristol Bay, measuring 273 and 278mm in body length (Sp. Nos. 13030, 13091).

D. IX–X, 16; A. 14–15; P. 18; V. I, 3

Head 2.40–2.44 in body length; depth of body 5.18–5.58. Snout 3.27–3.37 in head length; maxillary 1.98–2.04; depth of caudal peduncle 7.87–7.91; interorbital width 6.09–6.30; diameter of orbit 5.41–5.43; length of eye 7.15 7.71; length of upper preopercular spine 6.06 6.43; distance from tip of upper preopercular spine to tip of opercle 7.01–7.23; depth of head 2.76 2.78; third dorsal spine 3.27–3.70; fifth dorsal ray 2.41 2.59; longest pectoral ray 1.52 1.54; longest anal ray 3.27–3.50. Number of pores on lateral line 41–42; preopercular spines 3; gill rakers $\frac{1+7-8}{1+5-7}$ on the first gill arch.

In the adult, an irregular series of circular spinous plates appears above the lateral line, and strong spinous prickles below the lateral line; they are directed backward. Interorbital space rather smooth, and the postorbital spine very small. Color, in formalin generally fades.

This species is very nearly related to *M. verrucosus*, but differs from it in possessing a larger number of anal rays and pores on lateral line, and depth of head is smaller than that of the latter.

Myoxocephalus verrucosus (BEAN)

Three specimens were collected from Bristol Bay, measuring 287–329mm in body length (Sp. Nos. 13029, 13036, 13037).

D. X. 16; A. 12–13; P. 17; V. I, 3

Head 2.20–2.48 in body length; depth of body 3.81–4.58. Snout 3.04–3.43 in head length; maxillary 1.88–1.97; interorbital width 6.09–7.51; diameter of orbit 4.93 5.15; eye 6.53 7.32; depth of caudal peduncle 6.43–6.99; depth of head 2.04 2.14; length of upper preopercular spine 7.64–8.27; distance from tip of upper preopercular spine to tip of opercle 3.98–6.11; third dorsal spine 2.05–2.87; fifth dorsal ray 1.92–2.28; longest

pectoral ray 1.34–1.46; longest anal ray 2.55-2.83; longest ventral ray 1.96–2.30; middle of caudal ray 1.96-2.14. Number of pores on lateral line 39-42; preopercular spines 3; gill rakers $\frac{1+6-7}{1+6-7}$ on the first gill arch.

This species is very nearly related to *M. verrucosus* sub sp. *ochotensis* SCHMIDT, differing in respect to the smaller eye and the wider interorbital space.

The spinous bony plates are drawn up in about single file on upper lateral series and scattered in lower series, and one or three of them on the occiput. The nasal and upper orbital spines very small, and interorbital space rather smooth. Males have osseous tubercles on the inner side of rays of the pectoral and ventral fins, but they are absent in female. Very clear dark brown stripes are observed on fins, namely, two on first dorsal, five on second dorsal, four on pectoral, two or three on ventral, six on anal and three on caudal fins. Some clear white spots exist on the belly.

Dasycottus setiger BEAN

Only one specimen collected from Bristol Bay, measuring 256mm in body length, (Sp. No. 13028).

D. VIII, 14; A. 15; P. 25; V. I, 3

Head 2.34 in body length; depth of body 4.81. Snout 3.44 in head length; maxillary 1.98; depth of caudal peduncle 6.83; interorbital width 3.97; diameter of orbit 4.45. Number of pores on lateral line about 19; gill rakers $\frac{1+8}{3+9}$ on the first gill arch; branchiostegals 7; preopercular spines 4; uppermost preopercular spine is smaller than the other spines, and hooked in shape. Bony plates on nape and under the dorsal series. Teeth on vomer, but palatines toothless.

This species is very nearly related to *D. japonicus*, differing in length and shape of uppermost preopercular spine.

Gymnocanthus pistilliger (PALLAS)

Nom. Jap. Hage-kajika

Only one male collected from Bristol Bay, measuring 118mm in body length (Sp. No. 13096).

D. X, 15; A. 16; P. 19; V. I, 3

Head 2.87 in body length; depth of body 4.84. Snout 3.30 in head length; maxillary 2.67; depth of caudal peduncle 6.71; interorbital width 27.3; diameter of orbit 3.38; width of head 1.69; first dorsal spine 1.89; third dorsal spine 1.39; ninth dorsal spine 5.06; last dorsal spine 10.5; fourth dorsal ray 1.49; middle pectoral ray 1.41; longest anal ray 2.49; middle caudal ray 1.70. Number of pores on lateral line 41; preopercular spines 4; gill rakers $\frac{1+6}{1+3}$ on the first gill arch. Verrucacae on the back of pectoral and ventral fins. Spatula-like process on body side of under the pectoral. Especially, ventral

fin rays are developed, length of their longest ray 2.05 in body length.

Color brown about seven white spots on the first dorsal fin.

Gymnocanthus galeatus BEAN

Only one specimen collected from Bristol Bay, measuring 260mm in body length (Sp. No. 13026).

D. XI; 16; A. 19; P. 19; V. I, 3

Head 3.11 in body length; depth of body 5.00. Snout 4.22 in head length; maxillary 2.46; depth of caudal peduncle 6.74; interorbital width 12.4; diameter of orbit 3.88; width of head 1.34; first dorsal spine 2.88; third dorsal spine 2.68; ninth dorsal spine 4.89; last dorsal spine 11.3; fourth dorsal ray 2.53; middle pectoral ray 1.66; longest anal ray 3.68; longest ventral ray 1.93; middle caudal ray 2.02. Number of pores on lateral line about 42; preopercular spines 4; gill rakers $\frac{1+7}{1+7}$ on the first gill arch. Interorbital region covered with bony granulations. The spinous process are under the pectoral and base of pectoral fin.

Family **Agonidae**

Occa dodecaedron (*TILESIUS*)

Nom. Jap. Kamuto-sachi-uwo

Only one specimen collected from Bristol Bay, measuring 141mm in body length (Sp. No. 13097).

D. XI, 9; A. 16; P. 15; V. I, 2

Head 4.05 in body length; depth of body 7.92. Snout 3.66 in head length; maxillary 2.94; depth of caudal peduncle 6.96; width of caudal peduncle 8.48; interorbital width 5.89; diameter of orbit 5.19; length of first dorsal base 1.09; second dorsal base 1.29; longest dorsal spine 2.20; longest dorsal ray 2.23; longest anal ray 3.22; longest ventral ray 2.61. Length of longest pectoral ray 3.97 in body length. Number of plates on lateral line 37, and the plates of belly nearly smooth. Supraocular, occipital and temporal ridges spineless. Cheeks nearly vertical, suborbital ridge developed, spineless. A large spine projecting from preopercle.

Podothecus acipenserinus (*TILESIUS*)

Fifteen specimens collected from Bristol Bay, three specimens of which are male, measuring 196–244mm, while the other 12 specimens are female, measuring 143–231mm in body length (Sp. Nos. 12865, 13058-13064, 13069–13073, 13092, 13098).

D. VIII–IX, 7–8; A. 7–8; P. 16–19; V. I, 2

Head 3.40 3.82 in body length; depth of body 6.37–8.30. Snout 2.00–2.18 in head length; depth of caudal peduncle 13.0–15.9; width of caudal peduncle 10.9–14.8; interorbital

width 3.76–4.96; diameter of orbit 4.22–4.84; length of the first dorsal base 1.62–2.09; the second dorsal base 2.00–2.58; longest dorsal spine 2.26–2.84; longest dorsal ray 1.91–2.48; longest pectoral ray 1.32–1.51; longest anal ray 1.81–2.50; longest ventral ray 2.50–2.93 on male and 4.95–6.93 on female. Number of plates on lateral line 38–39; gill rakers $\frac{0-2+8-12}{0-2+10-13}$ on the first gill arch. Teeth on jaws.

This species is very nearly related to *P. vetermus*, but differs therefrom in that it is toothed on jaws and the number of pectoral rays is more than in *P. vetermus*. Especially distinctive of this species is that the depth of caudal peduncle is generally greater than its width.

Family **Cyclopteridae**

Aptocyclus ventricosus (PALLAS)

Nom. Jap. Hotei-uwo

The specimen which has come into our hands was collected by Mr. T. Igarashi, on the deck of the "Ginyō Maru", from among many salmon catches brought up by the "Zinkai Maru", in the area about 49°N, 170°E, on June 8, 1954 (Sp. No. 12977).

It seems that the present specimen may have been taken from stomach or mouth cavity of salmon or lancet fish, many deep scars were found, and these scars may be wound from sharp teeth, but the body is not sufficiently heavy to enable exact examination of the specimen. The measurements and counts of body part of the present specimen given in the following table (Table 5).

Family **Ammodytidae**

Ammodytes personatus GIRARD

Nom. Jap. Ikanago

Only one specimen was collected from Bristol Bay, on June 13, 1955, measuring 146mm in total length.

Family **Blenniidae**

Lumpenus lampetraeformis (WALBAUM)

Three specimens collected from Bristol Bay, measuring 242–314mm in body length (Sp. Nos. 13065–13067).

D. LXXII–LXXIII; A. 49–51; P. 15–16; C. 17–18; V. I, 3

Head 7.05–7.45 in body length; depth of body 15.2–16.7. Snout 3.42–3.81 in head length; maxillary 3.26–3.34; depth of caudal peduncle 4.57–5.27; interorbital width 5.35–6.38; diameter of orbit 4.63–5.27; middle dorsal spine 3.23–3.66; longest pectoral ray 1.26–1.33; longest anal ray 3.34–4.43; middle caudal ray 1.29–1.48; longest ventral ray 2.98–3.11. Number of gill rakers $\frac{0+14}{3-7+11-13}$ on the first gill arch. No teeth on palatines.

Table [illegible]. Measurements of body part of *Aptocyclus ventricosus* are expressed in ratio to body length (B. L.) and head length (H. L.).

Items	Measurement (mm)	Ratio to B. L.
Total length	151	
Body length	122	
Length of head	48	2.54
Depth of body	56	2.18
Distance between posterior margin of ventral disk and origin of anal fin	61	2.00
		Ratio to H. L.
Length of snout	15	3.20
Length of maxillary	15.5	3.10
Width of interorbital space	26.5	1.81
Width of head at cheek	34	1.39
Depth of caudal peduncle	11	4.36
Diameter of orbit	8	6.00
Diameter of ventral disk	26	1.84
Longest ray of dorsal fin	20	2.40
Longest ray of anal fin	18	2.67
Longest ray of pectoral fin	42	1.14
Longest ray of caudal fin	30	1.60
Base length of dorsal fin	24	2.00
Base length of anal fin	15	3.20
Base length of pectoral fin	34	1.39
Distance between anus and anal fin	22	2.18
Distance between posterior margin of ventral disk to anus	38	1.26
Number of dorsal rays	10	
Number of anal rays	8	
Number of caudal rays	11	
Number of pectoral rays (left : right)	20 : 20	

The present study. The first three or four rays of dorsal fin are short and almost free. [illegible] about [illegible] faint brown blotches of different sizes, some of them confluent and [illegible], and about seven clear cross bands on caudal fin.

Family Bathymasteridae

Bathymaster signatus COPE

The present one specimen has been received through the courtesy of Mr. T. Takeuchi [illegible] mm in total length. The detailed description of this species has already been by Sato and Ueno in [illegible]. See, Sato & Ueno's "On a rare fish, *Bathymaster signatus* COPE taken from the Northern Pacific and notes on allied species."

Bull. Fac. Fish. Hokkaido Univ. 4, (3). pp. 203–211.)

Family **Zoarcidae**

Lycodes turneri BEAN

A single matured female specimen, measuring 710mm in total length (Sp. No. 13080), taken at 58° 49′N, 168° 28′W, in Bristol Bay, was received through courtesy of Mr. K. Yamahira. Measurements and counts are given in Table 6 (Fig. 6).

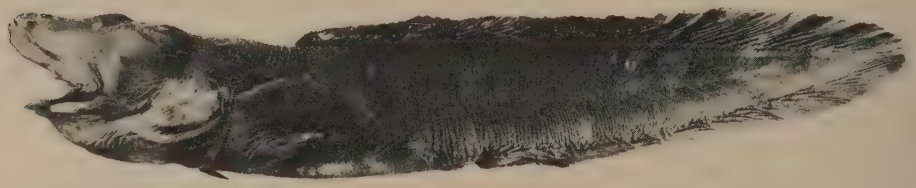

Fig. 6. *Lycodes turneri* BEAN, 710mm in total length (Sp. No. 13080)

According to Andriashev (1954), the present species has generally been treated as identical with *Lycodes polaris* and *L. coccineus* by older or recent ichthyologists, or with *L. angnostius* according to Vladykov. But, as a result of careful examination of *Lycodes* based upon the many recent specimens collected from the Arctic Seas and Sea of the Far East of the Soviet Union, the present species must be treated as a species independent from *L. polaris*, *L. coccineus* and *L. agnostius* because of having many remakable characters, longer dorsal and anal fins, more numerous fin rays and vertebrae, more depressed head, wider interorbital space, characteristic form of gill opening, and peculiar colourations.

Among the *Lycodes* from Bering Sea, the present species is most like *Lycodes mucosus coccineus*, but is distinguishable from it by entirely lacking scales, having wider interorbital space, more numerous vertebrae, and by its peculiar colourations.

Family **Pleuronectidae**

Atheresthes stomias (JORDAN & GILBERT)

Three specimens, measuring 458–483mm in body length, were collected from Bristol Bay (Sp. Nos. 12791, 13053, 13054) (Fig. 7).

D. 102–114; A. 84–87; P. 14 (eyed side); V. 6 (each side);
Lateral scales about 100; Gill rakers on the first arch 4+11–13

Head 3.51 3.66 in body length; depth of body 2.73 2.80. Snout 3.67 3.89 in head length; maxillary 1.63-1.79; interorbital width 12.70-13.61; diameter of orbit 4.55–5.67; depth of caudal peduncle 3.38–3.49; longest ray of dorsal fin 2.54–3.09; the same of anal 3.14–3.32; the same of pectoral (eyed side) 2.49–2.72.

Table 6. Measurements of body part of *Lycodes turneri* are expressed in ratio to body length (B. L.) and head length (H. L.).

Items	Measurement (mm)	Ratio to B. L.
Length of body	680	
Depth of body at dorsal origin	98	6.94
Length of head	200	3.40
Greatest width of head	163	4.17
Distance from ventral fin to anus	95	7.16
Distance from anus to posterior end of caudal fin	352	1.93
Distance from tip of snout to anus	359	1.89
Distance from tip of snout to dorsal fin	220	3.09
Distance from tip of snout to anal fin	353	1.92
Distance from tip of snout to ventral fin	143	4.76
		Ratio to H. L.
Length of snout	72	2.78
Length of maxillary	125	1.60
Length of mandible	84	2.38
Length of interorbital width	40	5.00
Diameter of orbit	20	10.00
Diameter of eye-ball	13	15.36
Height of dorsal fin	43	4.65
Height of anal fin	34	5.38
Length of pectoral fin	97	2.06
Length of ventral fin	25	8.00
Length of caudal fin	23	8.70
Length of gill opening	81	2.47
Length of postorbital part of head	116	1.73
Distance between both lower angles of gill opening	75	2.67
Length of palatine bone	15	13.31
Length of vomer	13	15.41
Width of head	163	1.23
Depth of head at occipital region	101	1.98
Interspace of both pectorals	80	2.50
Number of dorsal fin rays	86	
Number of anal fin rays	76	
Number of pectoral fin rays	19	
Number of ventral fin rays	3	
Number of caudal fin rays	11	
Number of gill rakers on the first arch	2+12	
Number of branchiostegal rays	6	

Fig. 7. *Atheresthes stomias* (JORDAN & GILBERT), 545mm in total length (Sp. No. 12791)

The upper eye reaching edge of head. Teeth are arranged in two rows on each jaw, and those on inner row are enlarged, thick, and movable, those on outer ones are smaller, sharply pointed and fixed on premaxillary and dentary bones. Gill rakers are slender, comb-teeth like, pointed at tips, and many minute serrations are present on their inner margins. Interorbital space is broad, furnished with 4–5 rows of small ctenoid scales. The middle rays of pectoral fin are branched. Some hindermost rays of dorsal and anal fin are also branched. Lateral line is slightly arched above the pectoral fin.

Hippoglossus stenolepis SCHMIDT

Nom. Jap. Ohyō

Nineteen specimens, measuring 241–560mm in body length, were collected from Bristol Bay (Sp. Nos. 12798–12801, 13050–13052, 13079, 13082–13085, 14099–14104, 14120).

D. 96–105; A. 70–77; P. 16–18 (eyed side); V. 6; Lateral scales 157–183; Gill rakers on the first arch 1–2+8–10; Branchiostegals 6

Head 3.49–3.85 in body length; depth of body 2.78–3.20. Snout 3.82–4.82 in head length; maxillary 2.74–3.14; interorbital width 7.40–15.26; diameter of orbit 4.64–7.21; depth of caudal peduncle 3.42–4.10; the longest ray of dorsal fin 2.30–2.94; the same of anal 2.51–3.03; the same of pectoral (eyed side) 1.93–2.38. Distribution of number of dorsal, anal and pectoral fin rays is presented in table (Table 7).

Hippoglossoides elassodon (JORDAN & GILBERT)

Nom. Jap. Uma-garei

Ten specimens were collected from Bristol Bay, measuring 271–375mm in body length (Sp. Nos. 12841–12846, 13055–13057, 14121) (Fig. 8).

D. 80–89; A. 61–68; P. 10–11 (eyed side); V. 6; Lateral scales 87–95; Gill rakers on the first arch 3–5+15–19; Branchiostegals 7

Table 7. Number of dorsal, anal and pectoral fin rays of 19 specimens of *Hippoglossus stenolepis* from Bristol Bay

Dorsal fin rays	96	97	98	99	100	101	102	103	104	105
No.	3	3	3	2	2	2	2	0	1	1

Anal fin rays	70	71	72	73	74	75	76	77
No.	2	2	0	4	2	4	2	3

Pectoral fin rays	16	17	18
No.	5	9	5

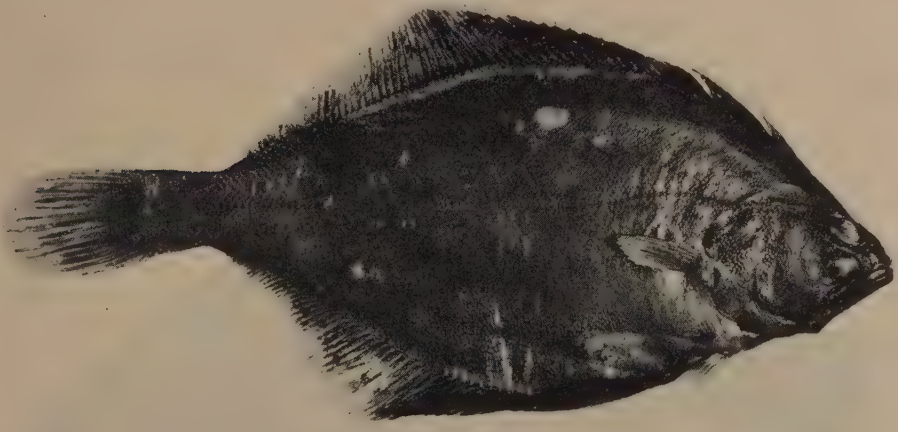

Fig. 8. *Hippoglossoides elassodon* (JORDAN & GILBERT), 415mm in total length (Sp. No. 13057)

Head 3.08–3.67 in body length; depth of body 2.07–2.36. Snout 4.87–6.78 in head length; maxillary 2.29–2.93; interorbital width 24.00–30.08; diameter of orbit 4.24–533; depth of caudal peduncle 2.60–3.91; longest ray of dorsal fin 2.10–2.85; the same of anal 2.10–2.84; the same of pectoral 2.05–2.93.

Hippoglossoides robustus GILL & TOWNSEND

Nom. Jap. Doro-garei

The present specimen measures 369mm in body length (Sp. No. 13076).

D. 73; A. 57; P. 9 (eyed side); V. 6; Lateral scales 87;

Gill rakers on the first arch 3+13; Branchiostegals 7

Head 3.55 in body length; depth of body 2.34. Snout 4.55 in head length; maxillary

2.74; interorbital width 26.00; diameter of orbit 5.78; depth of caudal peduncle 3.35; longest ray of dorsal fin 2.39; the same of anal 2.92; the same of pectoral (eyed side) 2.74.

Teeth are sharp, conical, and arranged in a single row on both jaws. Anterior-most teeth of upper jaw are enlarged. There are 6 distinct mucous pores on the side of lower jaw. Gill rakers are slender, comb-teeth like, but entirely smooth. The middle rays of pectoral fin are branched. No anal spines. Lateral line marks a low arch above the pectoral fin.

The present species very closely resembles *Hippoglossoides elassodon* in general forms, being distinguishable from it by the smaller number of dorsal, anal, and pectoral fin rays and gill rakers.

Inopsetta ischyra (JORDAN & GILBERT)

A single specimen from Bristol Bay, taken on May 5, 1953, measuring 456mm in body length (Sp. No. 12859) (Fig. 9).

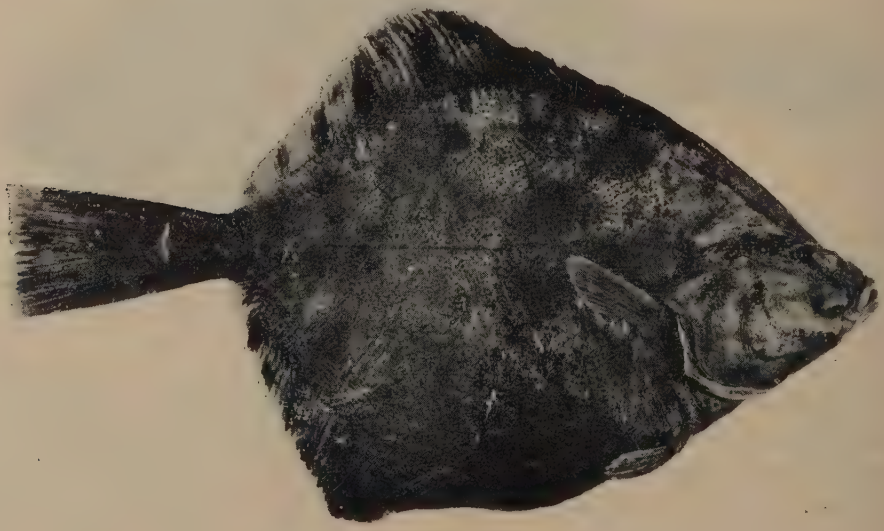

Fig. 9. *Inopsetta ischyra* (JORDAN & GILBERT), 545mm in total length (Sp. No. 12859)

D. 69; A. 49; P. 11 (eyed side); V. 6; Lateral scales 80;
Gill rakers on the first arch 2+7; Branchiostegals 7

Head 3.10 in body length; depth of body 1.78. Snout 4.59 in head length; maxillary 4.08; interorbital width 12.25; diameter of orbit 7.74; longest ray of dorsal fin 2.53;

the same of anal 2.26; the same of pectoral (eyed side) 2.41.

The upper profile of head is somewhat concave. Interorbital space is broad, slightly concave, furnished two irregular rows of rough ctenoid scales. There are 8 bony tubercles on occipital region behind the eye. Those tubercles are irregular in size and arranged in a short row. The lower eye is slightly in advance of the upper. Gill rakers are short, triangular, and their tips are bluntly pointed. All rays of dorsal and anal fin are covered with strong ctenoid scales. Anal spine is strong and sharply projected. There are some distinct broad black bands on the dorsal and anal fin. The scales on eyed side are almost ctenoid, above all, the those on head becoming strong ctenoid. Lateral line has a slight curve above the pectoral fin. The branched line of lateral line with a short prolongation which runs backward, and extends to under the ninth dorsal ray.

Lepidopsetta bilineata (*AYRES*)

Nom. Jap. Shumushu-garei

Twenty-eight specimens, measuring 149–384mm in body length (Sp. Nos. 12803–12824, 14122–14127), were collected.

D. 72-81; A. 55-62; P. 10-12 (eyed side); V. 6; Lateral scales 85-95; Gill rakers on the first arch 3-5+6-8

Head 3.07–3.69 in body length; depth of body 1.96–2.28. Snout 3.00–5.00 in head length; maxillary 3.75–4.85; interorbital width 17.5–29.3; diameter of orbit 4.21–5.61; longest ray of dorsal fin 2.04–2.68; the same of anal 2.13–2.80; the same of pectoral (eyed side) 1.95–2.28.

Teeth on both jaws are conical, arranged in a single row. Gill rakers are short, triangular, but sharply pointed. Lower pharyngeal bones are narrow, each one closed at anterior part in V-shape. Interorbital space with 3–4 rows of small ctenoid scales. The median rays of pectoral fin are branched. Anal spine is short but strongly pointed. Scales on eyed side are all ctenoid, whereas those on blind side are all cycloid. The variable number of dorsal, anal and pectoral fins are recorded in Table 8.

Table 8. Number of dorsal, anal and pectoral fin rays of 28 specimens of *Lepidopsetta bilineata* from Bristol Bay

Dorsal fin rays	72	73	74	75	76	77	78	79	80	81
No.	3	2	4	2	3	5	4	1	2	2

Anal fin rays	55	56	57	58	59	60	61	62
No.	1	5	3	5	4	4	2	4

Pectoral fin rays	10	11	12
No.	5	10	13

Limanda aspera (*PALLAS*)

Nom. Jap. Rosuke-garei

It seems that the present species is most common and most abundant among the flounders of Bristol Bay together with *Lepidopsetta bilineata* (*AYRES*); 28 individuals, measuring 159–359mm in body length, are found in our collection (Sp. Nos. 12825–12834, 12836, 12837, 12866, 13074, 13078, 13086, 13089, 14110–14119, 14128).

D. 64–73; A. 49–56; P. 10–13; V. 6; Lateral scales 78–89;
Gill rakers on the first arch 3–9+8–10

Head 3.14 4.07 in body length; depth of body 1.59–2.27. Snout 3.91-5.77 in head length; maxillary (eyed side) 3.28 4.41; diameter of orbit 4.33-6.52; interorbital width 11.1 21.4; depth of caudal peduncle 2.43-3.80; the longest ray of dorsal fin 1.77–2.27; the same of anal fin 1.69–2.35; the same of pectoral fin (eyed side) 1.62–2.12.

Eyed side of head and body covered with rough ctenoid scales; those on body arranged in irregular rows anteriorly and regular rows posteriorly, are hidden by the thin skin, and armed with a short, strong prickle which projects backward through the skin. Scales on head of eyed side are conspicuously rough, and armed with 8–9 shorter prickles. There is a conspicuous scale-bush in front of lower orbital rim. All fin rays of eyed side also covered with rough comparatively small ctenoid scales, but are entirely smooth on blind side.

Occipital ridges have no remarkable bony granules. Interorbital space is slightly convex, and covered with 1 to 4 rows of small ctenoid scales. Gill rakers are short, nearly triangular in shape, not armed with prickles. Lateral line has a high arch above the pectoral fin. Median rays of both pectorals are branched. There are yellow-orange bands along the dorsal and anal fin bases of blind side.

Limanda proboscidea GILBERT

Nom. Jap Hana-garei

Only one specimen, measuring 144mm in body length, is included in collections at hand (Sp. No. 13093).

D. 65; A. 49; P. 11; V. 6; Lateral scales 84; Gill rakers
on the first arch 5+10; Branchiostegals 7

Head 3.00 in body length; depth of body 2.21. Snout 4.00 in head length; maxillary (eyed side) 4.00; diameter of orbit 6.86; interorbital width 4.80; depth of caudal peduncle 3.43; the longest ray of dorsal fin 2.82; the same of anal fin 3.00; the same of pectoral fin (eyed side) 3.43.

The present species most resembles *L. punctatissima* (*STEINDACHNER*), but is distinguishable from it in following points:

1–Dorsal outline of head is more strongly curved, and snout is more projected.

2 -Lateral scales more numerous in number, namely 90–95 in the present species, but 65–78 in *L. punctatissima*.

3 -Color of body of blind side has a tinge of light-yellow uniformly, but lacks characteristic yellow bands running along the dorsal and anal fin bases.

4 -There is not a reticulate pattern formed by dark lines running along each row of scales on eyed side.

5 -In the female, scales on body are all cycloid in each side, while in the male, they are ctenoid on eyed side and cycloid on blind side (In *L. punctatissima*, scales on body are all cycloid in both sexes).

Pleuronectes pallasii STEINDACHNER

Nom. Jap. Tsuno-garei

Twenty-two specimens, measuring 250-482mm in body length, were collected from Bristol Bay (Sp. Nos. 12843, 12847–12858, 13048, 13049, 13075, 13088, 14105–14109).

D. 63–74; A. 47–54; P. 9–12; Lateral scales 78–86; Gill rakers on the first arch 2–4+5–7

Head 2.86–3.39 in body length; depth of body 1.72–2.03. Snout 4.00–5.78 in head length; maxillary 4.13–5.04; interorbital width 9.85–20.0; diameter of orbit 4.75–7.87; depth of caudal peduncle 2.85–4.17; longest ray of dorsal fin 2.23–3.10; the same of anal fin 2.10–3.17; the same of pectoral (eyed side) 2.05–3.31. Variable number of dorsal, anal and pectoral fin rays of 22 specimens are tabulated in Table 9.

Table 9. Number of dorsal, anal and pectoral fin rays of 22 specimens of *Pleuronectes pallasii* from Bristol Bay

Dorsal fin rays	63	64	65	66	67	68	69	70	71	72	73	74
No.	1	1	1	4	3	1	4	1	2	3	0	1

Anal fin rays	47	48	49	50	51	52	53	54	55
No.	2	1	1	3	4	4	2	4	1

Pectoral fin rays	9	10	11	12
No.	2	10	9	1

Upper profile of head is strongly concave above the upper eye. Interorbital space is broad, somewhat convex, smooth and without scales. Gill rakers are tubercular, their tips are bluntly pointed. Lower pharyngeal bones are massive, more than half of inner margin of each bone is united together, and they have 3 rows of molars, of which the most inner ones are larger. Anal spine is sharply pointed. Median rays of pectoral fin are branched. Lateral line has a short branch directed upward reaching to sixth or seventh

rays of dorsal fin. Scales are all cycloid, and are hidden in the thick bony skin, so that the surface of body of each side is very smooth.

Platichthys stellatus (*PALLAS*)

Nom. Jap. Numa-garei

Seven specimens collected from Bristol Bay, measuring 340–466mm in body length, of which two are right-headed individuals, others are left-headed. Though the relative ratio of occurrence of left-headed versus right-headed ones in Bristol Bay cannot definitely stated, it may probably be that right-headed ones are not so few as they are rare (Sp. Nos. 12802, 12838–12840, 13046, 13047, 13087).

D. 53-61; A. 39-43; P. 10-11; V. 6; Lateral scales 63-78;
Gill rakers on the first arch 3 5+7-9; Branchiostegals 7

Head 2.89 3.34 in body length; depth of body 1.08–1.83. Snout 4.43–5.57 in head length; diameter of orbit 6.16–8.10; interorbital width 9.31–17.86; maxillary (eyed side) 3.66–4.00; depth of caudal peduncle 3.05 3.98; the longest ray of dorsal fin 2.06–2.34; the same of anal fin 1.99 2.23; the same of pectoral fin (eyed side) 2.45–2.93.

Lower pharyngeal bones are wide, connected with each other in their anterior half, external form heart-like or arrowhead-like. The angle forming inner margins of the two pharyngeals is nearly right angle.

Many rough spinal tubercles are scattered on both sides of body, above all, those on head and body of eyed side are numerous and are closely scattered, so that surface of head and body is very rough. There is a regular row of similar tubercles along both dorsal and anal fin bases on eyed side. Dorsal and anal fins have 5-8, and 3-7 black vertical blotches respectively, and also, caudal fin marked by 2 6 similar but indistinct ones. Scales found only along the lateral line, others are reduced to spinal rough tubercles.

Family **Gadidae**

Gadus macrocephalus TILESIUS

Nom. Jap. Ma-dara

Eight specimens were collected from Bristol Bay, measuring 162-682mm in body length (Sp. Nos. 12792, 12793, 12797, 13017, 13042, 13043, 13094, 13095).

Theragra chalcogramma (*PALLAS*)

Nom. Jap. Suketo-dara

Six specimens were collected from Bristol Bay, measuring 161–607mm in body length (Sp. Nos. 12794–12796, 13018, 13044, 13045).

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脊椎骨数に見られる知内川のサケ魚群の特異性

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Peculiarity of Population of Chum Salmon in the Shiriuchi River in respect to the Vertebral Count

Tatsuro KUBO

Abstract

It has been remarked that the chum salmon of the Shiriuchi River are larger in size, than those of the other rivers in Hokkaido, that also, in the vertebral count and the number of lateral line scales, they tend to exceed the others.

Evidence from an experiment indicates that the difference in the vertebral count is significantly great between the two populations.

It was found that the average vertebral count of the chum salmon fry of the Shiriuchi River population is 67.26±0.77 (S. D.), and that of the Chitose River population is 65.13±0.85 (S. D.), as a result of an observation on the vertebral counts of chum salmon fry incubated simultaneously in the same trough.

Further, it is interesting that the vertebral counts of chum salmon fry of Shiriuchi River population are also more than those of fry from many hatcheries with the exception of the Yakumo Hatchery in Hokkaido, where the temperatures of the water for incubation are about 8°C.

緒　　言

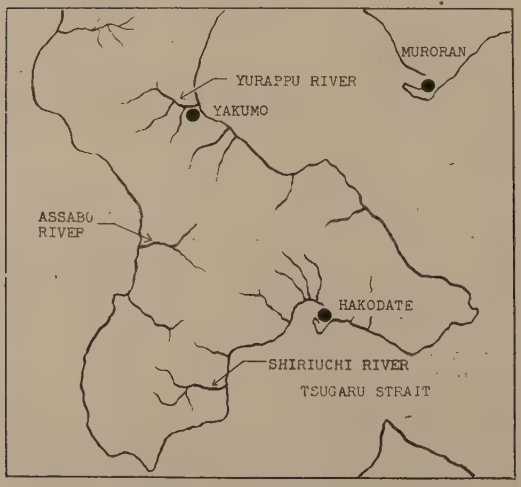

Fig. 1. Outline map of Southern Hokkaido, showing the Shiriuchi River

知内川（第1図）は北海道南部に於ける大型河川の一つであり，それに派上するサケは他の河川に派上するサケと比べて体成長が著しく大きく，又側線部のウロコの数の多い事は佐野・久保（1946）がすでに論じ，又久保（1947）はウロコの核心部の成長様式についても他に例の少い特異の型（B型）に属する個体の多い事を示した。更に久保（未発表）がその後二三の成魚の標本について調べた結果では，脊椎骨数に於ても多い傾向のある事を知つた。

筆者は知内川のサケの脊椎骨数がその魚群系統の特異性を示しているか否かを吟味する目的で，一つの簡単な実験を行つた。即ち，知内川に於てとれた多数のサケ親魚による卵子と他の河川の代表として千歳川に於けるそれとを同一条件の下に発生させて得た稚魚の脊椎骨数を比較した。又同時

に北海道内の主要な孵化場で人工孵化によつて生産されたサケ稚魚の脊椎骨数についても知内川のサケ稚魚のそれと比較観察した。尚この研究の詳細については現在も引続いて行つている。

本文を草するに方り，御指導を賜つた渡辺宗重先生，実験材料準備に多大の御援助を賜つた北海道水産孵化場（現北海道さけます孵化場）の各支場，事業場の諸彦，特に当時知内事業場に勤務された松本千代作，内藤知孝，野口正樹，蜂谷俊雄の諸氏，実験材料の飼育管理に一方ならぬ御苦労を煩した北大水産学部養魚実習場山本晋太郎，吉田弘の両氏並に孵化施設の一部を快く貸与された七飯村石井鉄雄氏に対して深く感謝する次第である。

材料及び方法

本研究に用いた材料の中で，特に実験的飼育に用いたものは第1表に示す通りであり，どちらの群のものも各々数十尾の親魚による卵子を混合したものの中より一部分抽出したもので，その収容の期日に25日の差があるが，しかし水温の環境には殆んど差異が認められない故に，同時に同一条件で発生，孵化及び飼育されたものと見做した。又第3表に示されたものの材料は北海道内の主要河川に配置された孵化場で人工孵化によつて生産された稚魚の中から標本として抽出されたものであり，それらの孵化場に於ける孵化飼育用水は水温8°C前後の湧水である。

Table 1. Material for an experimental incubation

Lot	Date of fertilization	Date of hatching	Water temperature
The Shiriuchi River	Dec. 15, 1952	Feb. 18, 1953	7.5–8.5°C
The Chitose River	Jan. 10, 1953	Mar. 10, 1953	

飼育実験は昭和27年12月から昭和28年5月にかけて行われ，後稚期に達した稚魚は中性フォルマリン又はアルコールで固定された。

脊椎骨数の計測に当つてはアリザリンレッドで染色した。計測の基準は久保(1950)，久保・小林(1953)の示したものと同じで尾中骨（urostyle）を除いている。

観察の結果及び考察

第2図及び第2表に示されたものは同時に同一条件で孵化飼育された稚魚の脊椎骨数に関する観察及び比較の結果であり，両群の脊椎骨数の差異は極めて大きく，驚くべき程である。

魚類の脊椎骨数は体節構成に基く各種の形質の中で最も重要なもので，特に資源学上，魚群系統の異同を示す手掛りの一つとして色々の魚種について論ぜられているが，その変異の要因として先天的なものと後天的なものとの両方がある事は明かで，脊椎骨数を魚群系統の比較の形質として用いる場合には原則として先天的な要因によるもののみを取扱う事が望ましい。しかし乍らサケに限らず魚類の脊椎骨数は後天的に卵の初期発生の時代の水温によつて支配される事は良く知られている所で，特に北海道のサケの場合，筆者自身が実験的に認めており(久保，1950及び未発表資料)，一般に低水温と脊椎骨数の増加及び高水温と脊椎骨数の減少との関連性とが認められる。従つて単にサケの或る魚群についてその発生時の水温を考える事なく，遺伝的特質としての脊椎骨数を論ずる事は厳密な意味では価値の少いものである。

サケの卵の初期発生の環境に於ける温度7～10°Cの湧水又は滲透水は人工孵化に於てのみでなく，天然産

Table 2. Difference in vertebral count of fry between the two populations, shown by an experimental incubation

Lot	Vertebral count						$\bar{x}$	$\Sigma(\bar{x}-x)^2$	Confidence interval in population mean (a=0.01)	Number of fish
	64	65	66	67	68	69				
The Shiriuchi River	—	—	14	52	28	6	67.26	59.32	67.06—67.46	100
The Chitose River	20	28	24	3	—	—	65.13	54.68	64.87—65.39	75

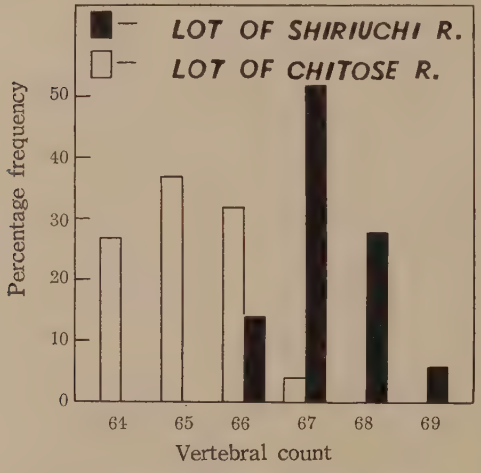

Fig. 2. Vertebral counts of chum salmon fry of the two populations, incubated experimentally

卵の場合に於ても良く認められる所であり（佐野1952），従つてそのような温度の水によつて発生孵化したサケ稚魚の脊椎骨数は便宜上，遺伝的な特質を示すものであると仮定しても良いであろう。

このような見地に立つて考察すれば，実験の結果として示された知内川のサケの脊椎骨数は少くも千歳川のサケのそれと比較して遺伝的に多いものであると言う事が出来よう。

第3表に示す所は北海道内の代表的河川に配置された孵化場で人工孵化によつて得られた稚魚の脊椎骨数であるが，多数混合された個体の中より抽出された標本であり，しかもこれら孵化場の用水の温度は8°C前後であるから，各々の河川系のサケの脊椎骨数の先天的なものを代表していると見做してよい。特に第2表に於ける知内川のサケ稚魚の脊椎骨数と比較する場合に興味あるものである。

即ち，一見して判る通り，八雲（ユーラップ川）の孵化場のものを例外として，各河川系のサケ稚魚の脊椎骨数は夫々その平均値は知内川のものよりも少く，見かけの上では比較的大きい値を示す釧路川系の稚魚でさえも脊椎骨数の母平均の信頼区間（a=0.01）は 66.58—66.98であり，知内川系の稚魚のそれ(67.06—67.46)に及ばない。

佐野（1951）によれば，北海道のアキアジは多数の魚群に分ける事が出来るが，産卵のための河溯に於て知内川のサケとユーラップ川のサケとは同じように北海道の東岸に沿つて南下するように推測され，又両群は体成長の大きい事，漁期が比較的遅く，その始と終が略々一致している事，同じように良く成熟している事，又ウロコの型の組成に於てB型が極めて多い事等，その近縁関係が予想されているが，上記の脊椎骨数の比較に於ても両群の間に差の明かでない事は，一層その事を暗示するようである。

更に一つ注意すべき事は，北海道の孵化場に於ては過去長年月の間，相互にサケマス卵の移殖，交換を数多く行つているので，若し各河川のサケの魚群に各々遺伝的特質があつたとしても，恐らく充分に混合されたものとなつているであろうと考えられる。所が只一つの例外として知内川のサケについては全く移出，移入のどちらをも行つていない。従つて現在に於ては知内川のサケの魚群は唯一の純粋に近い魚群として保た

Table 3. Vertebral counts of chum salmon fry from many hatcheries in Hokkaido

River	Year	Vertebral count									Number of fish
		64	65	66	67	68	69	70	$\bar{x}$	$\Sigma(\bar{x}-x)^2$	
Chitose	1950 (late)	11	23	8	3	—	—	—	65.13	30.20	39
Chitose	1951 (early)	4	16	21	22	5	—	—	66.12	73.05	68
Chitose	1951 (late)	4	10	6	4	1	1	—	65.65	39.89	26
Chitose	1952 (early)	2	15	23	6	—	—	—	65.72	25.30	46
Ishikari	1952	7	22	43	22	—	—	—	65.85	69.86	94
Nishibetsu	1951	2	20	34	37	5	—	—	66.23	79.60	98
Kushiro	1951	—	4	24	65	7	1	—	66.78	58.50	101
Tokachi	1951	—	5	37	27	1	1	—	66.38	34.75	71
Shibechari	1951	3	7	34	25	5	3	—	66.40	78.50	77
Assabu	1951	4	6	25	46	4	—	—	66.47	65.20	85
Yurappu	1949	—	—	5	12	5	3	2	67.44	34.65	17

れているものと考えられる。脊椎骨数に見られるその特異性はその事実を明かに例証しており，換言すれば毎年同一系統の魚群が知内川に派上していると言うことになるであろう。

ここに示された資料と比較するために，過去に於て北海道及びその周辺に於て調べられたサケの脊椎骨数の記録を引用すれば，平野・中川(1938) の調査の結果では浦河，雄武及び青森のサケ(夫々平均値は67.06，66.98，66.95) はかなり大きい値を示すが，他（網走のサケ，白サケ及びトキシラズ）は比較的小さい値を示し，又，三浦(1939) の観察では，西別川のサケ169尾の脊椎骨数はその変化範囲：64—68，モード：66，平均値：65.79 であり，何れの場合もここに示す知内川のサケの稚魚の脊椎骨数には及ばないようである。

摘　　要

1. 知内川のサケの卵(多数の親魚による)と千歳川のサケの卵(多数の親魚による)とを水温8°C (±0.5°C) の水槽中で殆んど同時に飼育孵化して得られた稚魚の脊椎骨数の比較に於ては，知内川系稚魚は千歳川系稚魚よりも著しく大きい値を示す。

2. 知内川系サケ稚魚の脊椎骨数は又北海道内各孵化場（孵化用水温約 8°C）に於て生産されたサケ稚魚のそれらよりも多い。但し近縁の系統と考えられるユーラップ川系稚魚のそれとの間に於ては差が明かでない。

3. 知内川系サケ稚魚の脊椎骨数が特に他の河川系のそれらよりも多い事は，過去に於て知内川のみが他とサケの移殖交換を行わなかつた事によるものと考えられ，この川のサケの魚群の独立性を強く例証している。

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追　　補

本文脱稿の後，北海道さけます孵化場小林哲夫氏より書信を受け，氏の昭和29年に於けるサケ親魚の脊椎骨数に関する調査結果（未発表）の引用を許された。ここに深く感謝すると共に，比較参照のためその資料を下に示す。

これによつても統計的検定にまつまでもなく明かに知内川のサケはその脊椎骨数に於て他のものを卓越していることがうかがわれる。

Table 4. Vertebral counts of chum salmon adults from many rivers in Hokkaido, 1954

River	Vertebral count							
	63	64	65	66	67	68	69	70
Shiriuchi	—	—	—	4	12	7	—	—
Chitose	—	9	35	36	14	1	—	—
Ishikari	2	6	19	29	35	7	1	1
Tokoro	—	4	30	45	15	6	—	—

From Kobayashi (unpublished data)

CONTRIBUTIONS TO THE KNOWLEDGE OF GRACILARIACEAE FROM JAPAN

II. On a new species of the genus *Gracilariopsis*, with some considerations on its ecology

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In 1949, Dawson erected a new genus, *Gracilariopsis*, taking *Gracilaria Sjoestedtii* KYLIN as its type species. His separation of this new genus from *Gracilaria* was chiefly based upon the differences in the internal strucutre of the cystocarps. In *Gracilariopsis*, the cystocarp is provided in its center with a small-celled, broad-based gonimoblast parenchyma, and it is destitute of the nutritive filaments connecting gonimoblast parenchyma with the pericarp. On the other hand, the cystocarp in *Gracilaria* is furnished in its center with a large-celled, usually small-based gonimoblast parenchyma bearing accessory nutritive filaments.

Dawson placed seven species in his *Gracilariopsis*. Later, Börgesen (1952) added one species from Mauritius, and Dawson (1953a) reported the occurrence of the genus in collections from Cuba and from Caribbean Sea and adjacent Atlantic coasts.

Toward the end of September 1955, the present writer had a chance to collect a pretty good amount of fertile specimens of gracilariaceous plants at Lake Akkeshi, Prov. Kushiro, Hokkaido, a lagoon 24.15 km in circumference, 31.99 km^2 in area and 6.9 m in the greatest depth. The lagoon is renowned in Japan for its abundant production of gracilariaceous agarophytes, which are harvested in a short season ranging from the end of September to early October. The yield in 1954 was estimated as much as 108000 *kan* (1 *kan* approximates 3.75 kg) in dry weight and in 1955 it is expected to be as much as 80000 *kan*. *Gracilaria confervoides* reported by Y. Yamada & T. Tanaka (1944) is, up to the present, the only species of the agarophyte that has been known to occur there.

The gracilariaceous plant found in this lagoon is used as an industrial material in manufacturing agar-agar. It is a dominant type. It grows adrift being deposited and half-buried on the muddy bottom or entangled among the bushes of *Zostera marina* together with *Chaetomorpha Linum*, *Laminaria longipedalis*, *Polysiphonia* sp. and *Laurencia* sp. etc. This type has always been found sterile. On the other hand, the fertile plant recently collected by the writer, which is always found attached to the substratum, has not been used as a material for agar-agar manufacture.

After careful examinations the writer concluded that the plant under consideration is a *Gracilariopsis* new to science. The diagnosis and a description of the anatomical characteristics of the plant are given below.

Gracilariopsis vermiculophylla OHMI, spec. nov.

Frondibus 4–30 cm, raro usque 80 cm altis, cylindricis, gracilibus, usque 3 mm diam. magnis; ramis in seriebus 2–4 ordinatis irregularibus, indeterminatis, in apice attenuatis; cystocarpiis subglobosis, 1200 μ vel minus diam., domoideis, basi paullo constrictis, subrostratis; gonimoblasto ipso e cellis quasi evacuolatis constante denseque protoplasmaticis composito, de quibus carposporangia radiant; neque gonimoblasto ut in *Gracilaria* conjugato cum pericarpio cellis nutrientibus; carposporis ovoideis, 30–50 μ longis; antheridiis in infundibulis apertis, profundis, conceptacularibus 70–150 μ altis, 45–120 μ latis in cortice impositis, nonnunquam super inflatas frondes vermiformas positis; terasporangiis ovatis, ad 60 μ longis, 42 μ latis per corticem passim dispersis, cruciatim divisis.

Japanese name: *Ogo-modoki*.

Habitat: At Lake Akkeshi, growing on oyster shells at Gomejima and on stones at the Tôbai coastal region, southeastern side of the lake, both facing tide-way, attached to the substratum by a discoid holdfast in the intertidal zone. Thus the present species shows a difference in habitat as compared with other types which grow luxuriantly, lying loose in more or less stagnant water protected by gregarious growths of *Zostera marina* at such places on Lake Akkeshi as Yamatosaki, Ikuraushi, and from Tôbai to Horonitai. At the Tôbai coast, mature tetrasporophytes of the present species are found most abundantly in the beginning of July and the mature carposporophytes somewhat later, whereas at Gomejima their period of most abundance comes nearly a month later.

Frond solitary or tufted, arising from a very small callous disc, usually 4–30 cm but sometimes up to 80 cm in length, cylindrical throughout, slightly flexous; main axis percurrent; branches long-attenuated, arising alternately on all sides from the main axis or sometimes one-sidedly, mostly with patent, sometimes even rectangular axils, branching up to four times, usually alternately but sometimes also subdichomously; branches of every type tapering toward apex, hardly constricted at the bases except those at the lower portion of the plant, 4.2–17 cm in length in the first order branches, 0.5–4 cm in the second, and shorter than 0.5 cm in the third order, the last one being simple, very short ramuli.

The main axis in the middle portion of the frond, in transverse section, consists in the medulla of 12–13 layers of large, round subisodiametric cells, up to 350 μ diam, with walls 5 7 μ to 15 μ thick; outer cells of the medulla merging gradually into a 2–3 layered subcortex composed of ovoidal cells, 30 μ high, 12–15 μ thick. Medullary cells contain several transparent, highly refractive globules, round or pod-like in shape, up to 75 μ × 60 μ in dimension. The nature of the globules was examined without useful results by the writer by means of various chemical reagents. Cortical cells, pigmented, are roundish, or more or less polygonal in shape as seen from the surface, 5 μ diam.

Fig. 1. A medullary cell in transverse section of a branch, showing several globules in the content ×380

or 4 μ × 6 μ, in section essentially arranged anticlinally in two layers, 12–15 μ to 20 μ high, 3–6 μ thick; surface jelly transparent, 6–12 μ thick.

Cystocarps subglobose, protruding up to 1200 μ diam., somewhat rostrate, ostiolate and a little basally constricted, scattered on all sides of branches, often aggregated, with a large gonimoblast parenchyma or placenta of small, densely massed, richly protoplasmic cells producing dense, radiating chains of ovoid carpospores almost fully filling the cystocarpic cavity; carpospores roundish or more or less elongated, measuring 30–50 μ in length, containing a conspicuous stellate, central body, nourished only by the gonimoblast, without nutritive filaments; placenta elongated and not lobed. Pericarp 130–150 μ thick, its cortex being composed of two layers of cells, outermost one is 9–15 μ high, 3–5 μ thick, while inner one is usually flat in shape, 8–12 μ high, 4–6 μ thick. Antheridia formed in cavities all over the surface of frond, but occasionally on slightly swollen, somewhat vermiform upper branches; cavities deep, open, conceptacular pockets mostly with a broad opening, 70–150 μ deep and 45–120 μ wide, well-separated by mediately anticlinally modified cortex; in surface view, mostly elongated longitudinally along the frond axis. Tetrasporangia scattered over the surface of frond, circular in shape as seen from surface, up to 42 μ diam., cruciately divided, rose-red in color, borne in a somewhat nemathecially modified cortex with elongated outer cortical cells which are up to 60 μ high

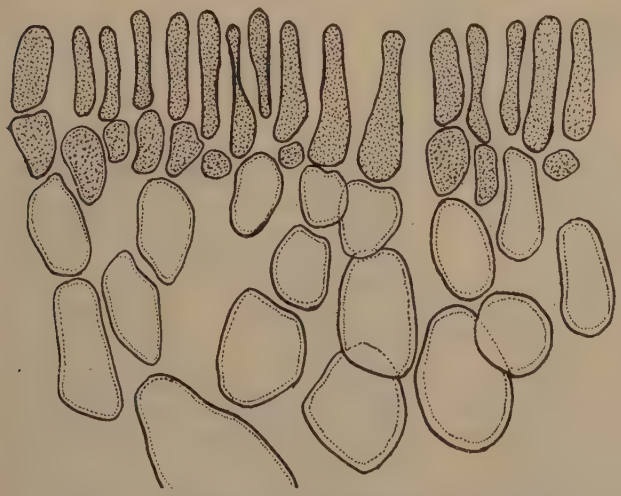


Fig. 2. Transverse section through a vegetative portion of frond, showing pigmented cortex ×760

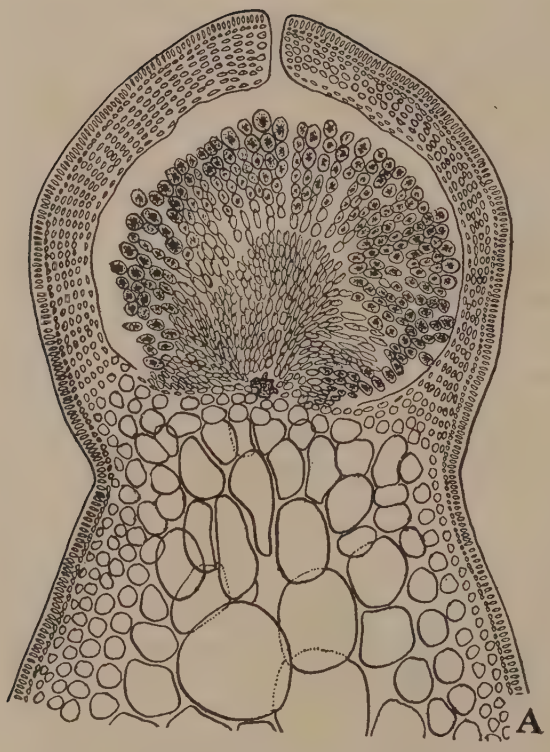


Fig. 3. A. Vertical section through a mature cystocarp ×74

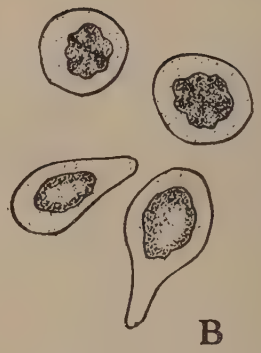


Fig 3. B. Carpospores showing a stellate central body ×760

and 42 μ thick in transverse view; they stain deep red with iron alum acetic carmine against other feebly stained tissues. These three kinds of reproductive organs are, of course, ordinarily formed on different plants.

In some specimens, tetrasporangia and antheridia occurred mixed together. These were scattered over the surface of the frond separately or gathered in small irregular groups which show no elevation above surface. When placed solitarily the antheridial cavity is broadly urn-shaped or deep pocket-like, well-separated from others by somewhat modified cortical cells, but when packed together, oblong. They have a somewhat narrowed opening and are about 45 μ to 70–150 μ deep, 24 μ to 45–120 μ wide in transverse section and 90–150 μ deep, 50–60 μ wide in longitudinal section.

The occurrence of sexual and asexual organs on one and the same individual has been frequently observed in Florideae by various investigators as mentioned by Fritsch (1945, pp. 723–725), and in the genus *Gracilaria* by Church (1916) and Börgesen (1950).

In the present species, however, both kinds of reproductive organs were abundantly present and mixed rather densely together, e. g., 5–7 or even over ten antheridial cavities were observed together with many tetrasporangia in a single microscopic field, 330 μ in diam. Yet after all, such a coexistence of different kinds of reproductive organs on one

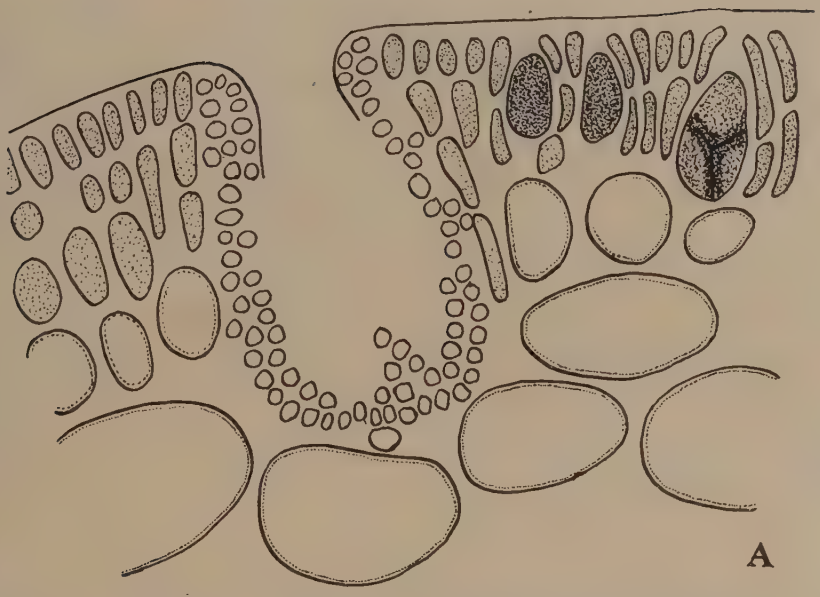
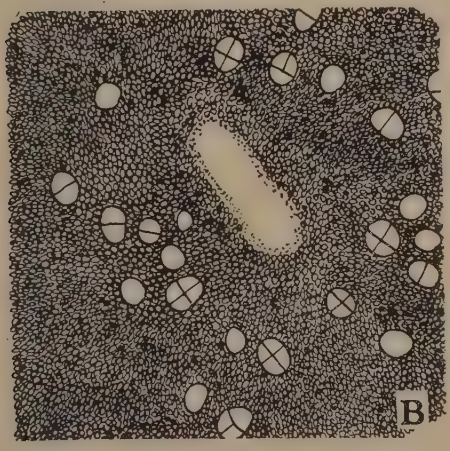


Fig. 4. A. Transverse section through a tetrasporic frond, showing three tetrasporangia together with an antheridial conceptacle ×420



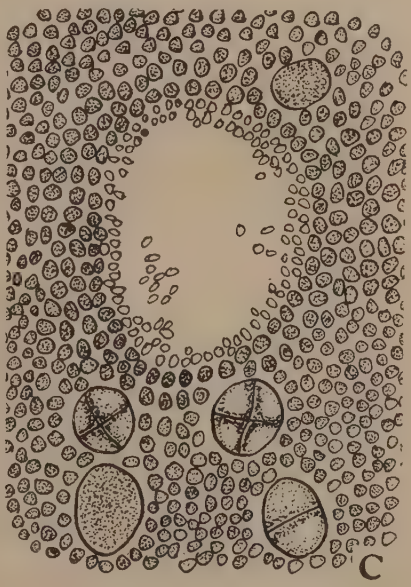


Fig 4. B. Surface view of the same frond as in A. ×127

C. Surface view of the same, more highly magnified ×420

individual cannot be considered as a specific character. Substance cartilaginous and the plant often imperfectly adheres to paper upon drying. Color dark red or rather blackish.

Dawson has kindly suggested to the writer in personal communication that, "the present plant may very well be an undescribed *Gracilariopsis* although the plant approaches both *G. robusta* and *G. rhodotrichia*". It apparently differs from the former in the appearance of the gonimoblast placenta and in the shape of the antheridial cavity as well as in the small size of its frond, and from the latter in its rather robust frond, in having larger medullary cells, cystocarps and antheridial pockets, as well as in somewhat modified cortical cells surrounding tetrasporangia.

Thus, the writer has concluded that the present species is new to science.

In conclusion, the writer wishes to express his gratitude to Prof. Jun Tokida for his kind direction. Sincere thanks are also due to Dr. E. Y. Dawson for his kindness in various ways. He is much obliged to Messrs. H. Okesaku and S. Sasaki of the Kushiro Station of Hokkaido Regional Fisheries Research Laboratory for their assistance in collecting materials of the present study.

Summary

1. The discovery of a new species of *Gracilariopsis*, *G. vermiculophylla* is herein reported on the basis of the material from Lake Akkeshi, Prov. Kushiro, Hokkaido. This is also the first record of the genus in Japan.

2. The new species seems to be somewhat related to *Gracilariopsis robusta* and *G. rhodotrichia*. However, it differs from *G. robusta* in the texture of both male and female sexual organs as well as in the size of the frond, and from *G. rhodotrichia* in having somewhat modified cortical cells surrounding tetrasporangia, in having larger medullary cells, cystocarps and antheridial cavities and in its rather robust frond. Hence the writer has come to the conclusion that the present species is new to science.

3. A brief note is also given on the ecology of the species in question comparing it with that of the dominant type of the gracilariaceous agarophytes in the lagoon.

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Plate I. Fig. 1. Habit of a tetrasporic plant
Fig. 2. Habit of a female plant

Plate II.

Fig. 1. Habit of a male plant

Fig. 2. Part of a frond bearing tetrasporangia together with antheridial conceptacles

REPORT FROM THE "OSHORO MARU" ON OCEANOGRAPHIC AND BIOLOGICAL INVESTIGATIONS IN THE BERING SEA AND NORTHERN NORTH PACIFIC IN THE SUMMER OF 1955

I. Programme of Investigations and Records of Eye Observations of Sea-Birds and Marine Mammals *

Sigeru MOTODA and Takeji FUJII

Faculty of Fisheries, Hokkaido University

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I. Introduction

Participating in the North Pacific Oceanographic Expedition (Norpac Expedition) coordinated by the oceanographic institutions of Japan, Canada and the United States, the training ship "Oshoro Maru" of the Faculty of Fisheries, Hokkaido University, in Hakodate, Hokkaido, made a research and training cruise from Hakodate to Seattle and return, traversing the Bering Sea on the outward course and the northern North Pacific on the homeward course during the period from June to August, 1955. The sea area assigned to be investigated by the "Oshoro Maru" was the Bering Sea, north of the Aleutian Islands extending from off the east coast of Kamchatka in the west, to Bristol Bay in the east, and north to about latitude 60° N.

In planning the investigations by the "Oshoro Maru", as a part of the Norpac enterprise, a special research committee was organized in the University from staff members who have taken responsibility for the studies in respect to their specialities. The results of the investigations will be published in successive papers under their sponsorship. The committee comprises the following persons:

Professor	Sigeru Motoda, D. Agr.	(Plankton)
Professor	Shin-ichi Satô, M. Sci.	(Ichthyology)
Professor	Naoichi Inoue, D. Sci.	(Turbidity, radio-activity)

* おしよろ丸北洋調査報告 No. 4 (1955年度)

Assistant Professor	Hideto Kotô, M. Sci.	(Physical oceanography)
Assistant Professor	Kenji Katô, M. Sci.	(Chemistry)
Assistant Professor	Tatsurô Kubo, B. Fish.	(Racial investigation of salmons)
Assistant Professor	Takeji Fujii, B. Fish.	Captain of the ship (Navigation and fisheries)

The 1955 cruise was the third one for the "Oshoro Maru" to make to the Bering Sea since the end of World War II. Referring to the results obtained from the two preceding cruises (Mishima & Nishizawa, 1955; Motoda & Kawarada, 1955) and from data provided by other ships (*ref.* Watanabe, 1954) it was desired to lay stress upon research in the most interesting areas; that is, off the east coast of Kamchatka, in which severely cold water is still to be found at around 100 metre depth in summer, and also the vicinity of the Aleutian Ridge over which warm water of low salinity from the east is flowing from the Pacific side into the Bering Sea. The western front of this warm water progressively moves westward with the progress of the season from spring to summer possibly having certain relation to the reduction of the above noted severely cold water in the deep. This front is considered to have certain significance in respect to the location of salmon fishing grounds. However, in making a research cruise roughly covering the whole of the Bering Sea, there was insufficient time and fuel to permit the carrying on of observations in detail in the above interesting areas. The final plan for the cruise was nearly the same as the actual performance.

II. Ship

The "Oshoro Maru" (fig. 1) is owned by the National Government of Japan and placed under the management of the Faculty of Fisheries, Hokkaido University. She was built in 1927 as a training ship of the College of Fisheries, Hokkaido Imperial University, in Sapporo, which was the predecessor school of the Faculty of Fisheries. Her original style was that of a barquentine sailing vessel, 471.76 gross tons, installed with auxiliary Diesel engine, 450 HP, but during World War II the sailing equipment was entirely removed; the mainmast and bowsprit were

Fig. 1. Training ship "Oshoro Maru" anchored in Hakodate (photographed by Mr. R. Maeda)

also taken away. In 1952 she was enlarged on the occasion of reconstruction; the hull was elongated by five metres in the middle portion, and the engine was renewed. Her particulars at present are listed below:

Gross tonnage:	616.72 tons	Maximum speed:	11.28 knots
Net tonnage:	213.52 tons	Cruising speed:	8.50 knots
Displacement:	969.01 tons	Fuel capacity:	110 tons
Length:	46.79 metres	Fresh-water capacity:	126 tons
Breadth:	9.14 metres	Range of cruise:	7200 miles
Depth:	4.79 metres	Wireless transmitter:	500W, 250W, 50W
Main engine:	Diesel 800 HP	Number of complement:	85 men

The ship was originally built for use entirely in training cadets in navigation and fisheries, having no equipment for oceanographic research, except only sounding winches, and no adequate accommodation for researchers. Such lacks were not corrected on the occasion of reconstruction. In making the present research cruise, the Captain's reception room was temporarily furnished with requisites for chemical analyses, but there was no space left to provide good accommodation for the scientists; they were compelled to use the spare cadet's berths, a berth for patient in the dispensary and a sofa in the Captain's reception room. The general arrangement of the ship is illustrated in fig. 2.

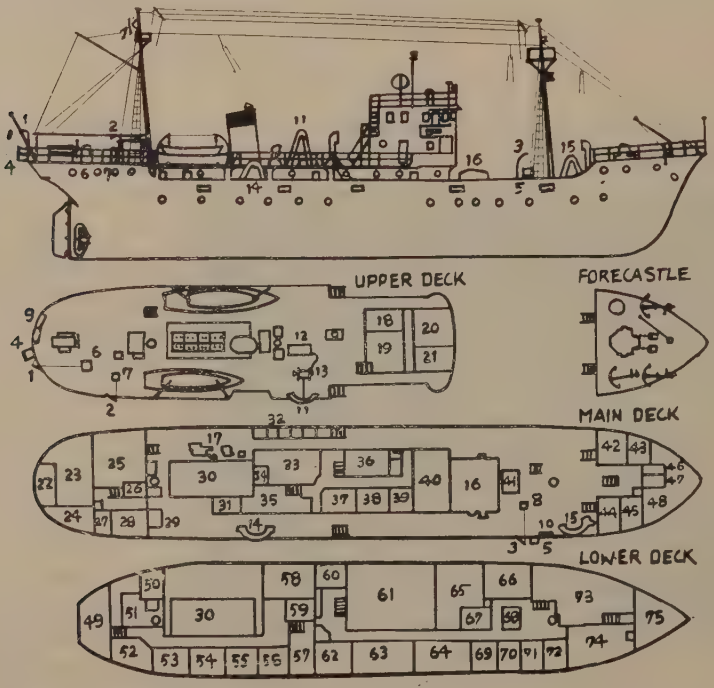

Fig. 2. General arrangement of "Oshoro Maru" (from blue print)

1. Hydrographic davit (upper deck, stern)
2. Hydrographic davit (upper deck, starboard)
3. Hydrographic davit (main deck, starboard)
4. Hydrographic stage (upper deck, stern)
5. Hydrographic stage (main deck, starboard)
6. Electromotive hydrographic winch(upper deck)
7. Spare hand hydrographic winch (upper deck)
8. Hand hydrographic winch (main deck)
9. Nansen bottle carrier (upper deck, stern)
10. Nansen bottle carrier (main deck, starboard)
11. Gallows for turbidity-meter provisionally set
12. Meter part of turbidity-meter
13. Drum for cabtyre cord of turbidity-meter
14. Trawl gallows (after)
15. Trawl gallows (fore)
16. Trawl winch
17. Canning machine
18. Chief wireless operator (1 berth)
19. Wireless room
20. Captain (1 berth)
21. Chemical laboratory
22. Store
23. Steering engine room
24. Store
25. Provision store
26. Photographic dark room
27. W C
28. Scientist's store (2 berths, but not usable during ocean-going)
29. Cold store
30. Engine opening
31. Coal bunker
32. W C
33. Lavatory
34. Bath
35. Galley
36. Chief officer (1 berth)
37. Second officer (1 berth)
38. First officer (1 berth)
39. Pantry
40. Saloon
41. Hatch
42. Cooks and boys (4 berths)
43. Petrol store
44. Bath
45. W C
46. Lamp store
47. Paint store
48. Store
49. Provision store
50. Engine store
51. Rice store
52. Store
53. Second engineer (1 berth)
54. First engineer (1 berth)
55. Chief engineer (1 berth)
56. Junior wireless operator (1 berth)
57. Purser (1 berth)
58. Third officer and third engineer (2 berths)
59. Gyro compass room
60. Dispensary (1 berth for doctor and 1 berth for patient)
61. Cadet's dining room and lacture room
62. Cadets (6 berths)
63. Cadets (8 berths)
64. Cadets (8 berths)
65. Cadets (10 berths)
66. Scientists (8 berths)
67. Refrigerating machine
68. Hatch
69. Boatswain (1 berth)
70. No. 1 oiler (1 berth)
71. Chief steward (1 berth)
72. Store
73. Quarter masters and sailors (12 berths)
74. Oilers and firemen (8 berths)
75. Cordage store

III. Equipment

Fifteen Nansen bottles, twenty protected reversing thermometers and seven unprotected reversing thermometers were provided for the present cruise. One of three hydrographic winches was provided with 3 HP electric motor while the other two, one for spare, were operated by hand. On these winches twisted steel wire of 2.7 mm diameter was wound. Only the above classic instruments were available for regular hydrographic observations, no recently developed instruments, such as Geomagnetic-electrokinetograph (GEK) and Bathy-thermograph (BT), being provided.

Fig. 3. Trubidity-meter on deck
T: Turbidity-meter
C: Cabtyre cord wound on the drum
M: Meter part

For measuring the turbidity of sea water *in situ* a turbidity-meter (fig. 3) constructed according to the design of Prof. N. Inoue of the University was prepared. This turbidity-meter was somewhat different from the original type reported in Fukuda *et al.* (1954).

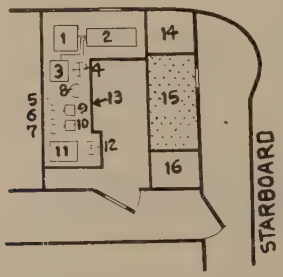

Fig. 4. Arrangement of chemical laboratory (designed by Asst. Prof. K. Katô)
1. Stabilizer for light source
2. Phototube colorimeter
3. Stabilizer for electric tube
4. Gimbals supporting a meter part
5. EDTA for Ca determination
6. N/100 HCl for alkalinity determination
7. N/100 $Na_2S_2O_3$ for oxygen determination
8. Heater
9. Magnetic stirrer
10. Magnetic stirrer
11. Glass electrode pH meter
12. Molecular filter assembly
13. Vacuum pump (beneath the table)
14. Locker
15. Sofa
16. Washstand

In the chemical laboratory (figs. 4,5) which was converted from the Captain's reception room such apparatus, as glass electrode pH meter, molecular filter assemblage and phototube colorimeter, were provided in accordance with recent advances in marine chemistry. Two magnetic stirrers were provided for convenience of rapid titration aboard. The arrangement of these pieces of apparatus was made by Asst. Prof. K. Katô.

Six sorts of plankton samplers were prepared. The standard net, so called "Marutoku Net", which was standardized by Mr. Z. Nakai of the Tôkai Regional Fisheries Research Laboratory, is conical in shape, 45 cm in mouth diameter, 100 cm in length along the side of cone, and made of coarse bolting silk, GG 54, *i.e.*, 52.5 meshes per linear inch, having

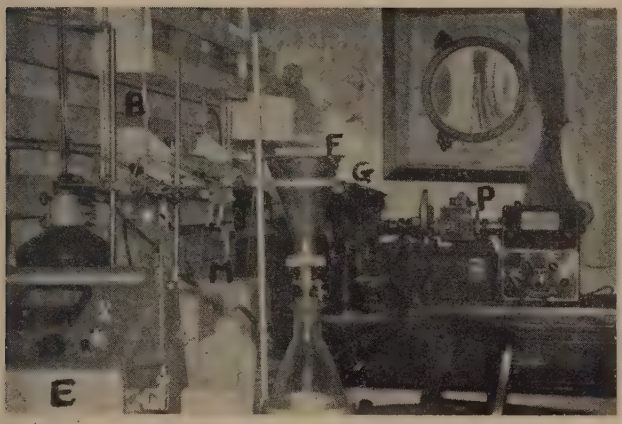

Fig. 5. Inside of chemical laboratory (photographed by Mr. M. Oguro)

P: Phototube colorimeter
G: Gimbals supporting a meter part
B: Burette
M: Magnetic stirrer
F: Molecular filter assembly
E: Glass electrode pH meter

0.33 mm of approximate mesh aperture. In the present cruise use was made of a net having side length of 165 cm and the same mouth diameter as the original type. Two such nets were prepared for the cruise.

A considerably large net, being 63 cm in mouth diameter, 300 cm in total length, and made of coarse bolting silk, GG 40, *i.e.*, 39 mehes per linear inch, in the lower 265 cm of the cone and of shrimp netting in the upper 35 cm, was prepared for deep haul.

A "Twin Net" (fig. 6), more simplified than the original type (Motoda, 1955), was prepared for making frequent deep haul. Each net of the twin has a size of 10 cm along the side of the square mouth and 50 cm in length along the tapering bag of bolting silk, GG 56, *i.e.*, 54.5 meshes per linear inch. A piece of cloth was sewed on inside the net. This is a device for preventing the outflow of materials.

Fig. 6. Twin net for deep haul

For sampling the microplankton in shallow layers two fine mesh nets were provided, 20 cm in mouth diameter and 70 cm in length, made of fine bolting silk, XX 16, *i.e.*, 157 meshes per linear inch.

A "Handy Underway Plankton Catcher, Model II" (fig. 7) (Motoda, 1954) was provided for this cruise. The inserted net was selected to have comparatively fine meshes of bolting silk, XX 13, *i.e.*, 129 meshes per linear inch.

For sampling fish-larvae and large plankton animals at the surface, two fish-larva nets were provided. The net used was a standard size in Japan, that is 130 cm in mouth diameter, 450 cm in length, and made of stramin in the upper 300 cm and of coarse bolting silk,

Fig. 7. Handy underway plankton catcher, model II

GG 54, in the lower 150 cm. One of these nets was lost at the first time of collection.

A diving dredge, the same type as the Scripps Dredge, but smaller in over-all, was provided for sampling comparatively large bottom animals.

All of the samples of water and chemical reagents were kept in polyethylene bottles for convenience of treatment without anxiety about breaking. Plankton specimens were usually preserved in glass vials and the specimens obtained from fish-larva net were stored in larger glass bottles. The sum total of the bottles and vials came to 2647; *viz.*, 4 polyethylene bottles of five litre capacity, 3 of two litre capacity, 340 of one litre capacity, 200 of 250cc capacity, 1500 of 100 cc capacity (for chlorinity determination), 400 glass vials for plankton specimens and 20 larger glass bottles for specimens of larger animals. The specimens of fish were stored in tanks with formalin liquid.

All of the above instruments and bottles were those manufactured in Japan, except the molecular filters made in Germany.

IV. Persons in Charge of Research Work at Sea

The present cruise was carried out under the command of Captain T. Fujii, carrying on board 12 officers, 23 crew members, 32 cadets and 10 scientists; total 78 persons aboard. The Captain and officers took responsibility for training of cadets in navigation, fishing operations and in general duty alloted for seaman.

The scientific party that engaged directly in the research work was composed of the following persons:

Professor	Sigeru Motoda, D. Agr.	(Leader)
Assistant Professor	Kenji Katô, M.Sci.	(Chemistry)
Research Assistant	Kiyû Kobayashi, B. Fish.	(Fish)
Research Assis ant	Miki Oguro, B. Fish.	(Chemistry)
Research Assistant	Masaaki Fukuda, M. Sci.	(Turbidity)
Graduate Student	Reiichi Maeda, B. Fish.	(Plankton)
Graduate Student	Tamitomo Kashiwakura, B. Sci.	(Chemistry)
Graduate Student	Nobuo Yamada, B. Fish.	(Chemistry)
Technical Employee	Kenji Tamukai, B. Fish.	(Turbidity)

In addition, Mr. H. Fukataki, Technical Official of the Japan Sea Regional Fisheries Research Laboratory, Fisheries Agency, in Niigata, joined the scientific members in helping with the research work at sea. The Captain and deck officers also participated in the research work, particularly on the meteorological observations and gill-net

operations. Their names are listed below:

Captain, Assistant Professor	Takeji Fujii, B. Fish.
Chief Officer, Research Assistant	Shigeo Abe, B. Fish.
First Officer, Research Assistant	Shôji Saitô, B. Fish.
Second Officer, Research Assistant	Kiyoshi Masuda, B. Fish.
Third Officer	Satoru Nishiyama, B. Fish.

Mr. Akira Togashi, ship's Purser, has also assisted in the researches by making eye observations on sea birds. Other crew members and cadets always assisted in the research work at sea while they were on watch duty.

V. Cruise Performed

The "Oshoro Maru" departed from Hakodate on June 21, sailing northward against the Oyashiwo Current (Kurile Current) off the east of the Kurile Islands. Entering into this water of grayish green colour the seamen said that sea began to smell of salmon. It is said that skilful fishermen can distinguish a good water for salmon fishery by the particular smell different from that of other waters. Most of the days the ship was covered with heavy fog, and her wake was shimmering with the luminescence of plankton at night. From hourly measurement of the temperature remarkably low values were obtained, as low as 2.7 °C, at the surface at 47°12'N, 154°19'E, the cold water possibly coming from the Okhotsk Sea passing between the islands of Kurile Chain.

The ship arrived off the south-western coast of Kamchatka on June 26. The hydrographic casts and plankton samplings as well as salmon gill-net operations were begun from this day. The ship turned to the east along about latitude 53°N. From Attu Island she steered for the north-west, but soon had to stop for a day from noonon July 3, because an atmospheric depression (998 milibar) was approaching to the north of the ship. After the depression has passed over, the ship continued her north-westward sailing, and at St. Os 11 off Karaginskii Island an unexpected temperature as high as 6.6°C at the surface was obtained. After sailing to the east for some time the vessel sailed southward to near Attu Island and then eastward to near Kiska Island.

When she was on this course a depression (994 milibar) passing to the north just at this time caused a westerly gale, about 15 m/sec, in the area around the ship. After carrying out the hard work of hydrographic observations at St. Os 18 and Os 19, she traversed Bower's Bank, which is located at about longitude 180°, and occupied St. Os 20. Crossing longitude 180° the date of July 10 was doubled. The bank was then traversed twice, again back westward and again eastward, four further hydrographic casts being made in the vicinity of the bank. The "Oshoro Maru" again steered for the north, going on before St. Os 27 was reached at 0810 on July 12. About this time the sea became rough; the hydrographic work at this station was very hard, angle of suspended wire reaching about 70 degrees. Heavy waves coming from south made impossible

the ship to steer for the east. At 0300 on July 13 she found herself located in a very low depression (985 milibar), and she was forced to continue southward sailing against the wind. When the wind changed to west at 1000 of this day she could steer for Bristol Bay, and was driven by the powerful stern wind, but no hydrographic observations could be carried out before St. Os 28 was reached on July 14. Sailing over to the north of the Pribilof Islands and occupying four shallow hydrographic stations the vessel reached Bristol Bay in the morning of July 16. There she met with the Japanese Crab-Fisheries Mother Ship, "Tôkei Maru," and anchored until the morning of July 19.

The "Oshoro Maru" approached Unimak Island, which lies at the end of the Alaska Peninsula, at dawn on July 20. It was the first sight of land so near since departure from Japan. Everybody on board was impressed by the snow-capped volcances on this island, *viz.*, Shishaldin, Poglomni, etc., shining in the growing morning light in what appeared a desolate neighbourhood. The ship sailed into the Pacific passing through Unimak Pass in the afternoon of this day. Three hydrographic stations were occupied in the Pacific before the ship reached about latitude 52° N. She must have traversed the great current rip in the south of Unimak Pass, as many birds and fur seals were accompanying her and many "bull kelps," *Nereocystis Lütkeana POST. et RUPR.*, were drifting here and there. Small jelly-fish were also abundantly seen in the sea; probably on account of that the samples in the fish-larva net emitted a considerable luminescence.

It was nearly always misty and cold in the Bering Sea, and on only a few days was the sun bright enough to enable men on board the vessel to enjoy basking on the deck, but later, on the course from Unimak Pass to the American coast, the atmosphere became warm and comfortable, though the weather was still often misty or rainy. The "Oshoro Maru" arrived at a point off Vancouver Island at about noon on July 27 and stopped engine until the next morning to adjust the day of arrival at Seattle. She anchored in Seattle for ten days from July 29 to August 8 for refueling and laying in supplies. All of the expedition members aboard the ship greatly enjoyed the stay in this city.

On the return voyage starting August 8 the course of the ship was set to follow a more southern route than the Great Circle course of the ocean liners. The return voyage was made in haste because one of crew suffered a heart attack on August 14 at sea; the hydrographic stations originally plannned in the western part of the northern North Pacific were not occupied. During the first half of the homeward course the ship suffered nearly constantly from heavy pitching because of head winds, but she arrived safely at her home port, Hakodate, on August 29.

The cruise covered 10370 miles in 60 days at sea in total; the approximate location of the track is illustrated in fig. 8.

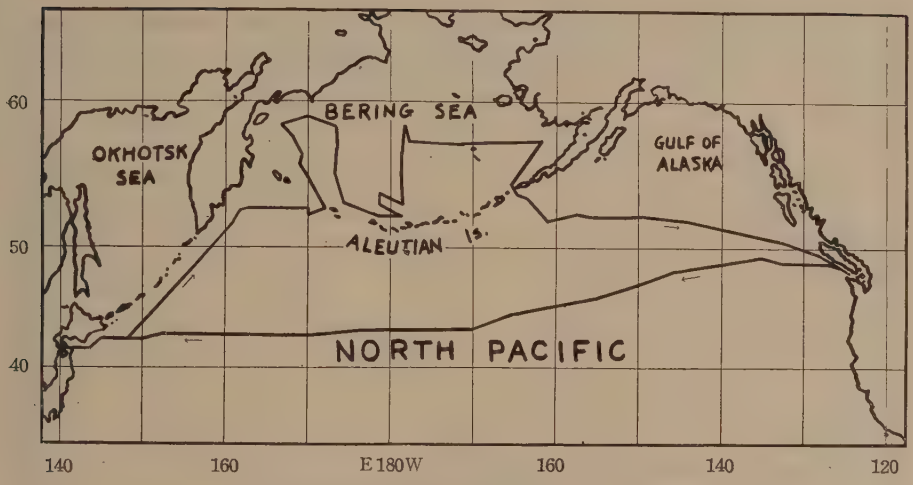

Fig. 8. Course of the "Oshoro Maru" on the present cruise

VI. Works Performed at Sea

Regular meteorological observations at every-three-hour interval were carried out at sea covering the whole course of the outward and homeward cruises under the responsibility of ship's officers. The surface water was dipped at every hour while underway for measurement of the temperature at the sea surface, while the surface water for determination of chlorinity was dipped four times a day.

The hydrographic stations occupied were 37 in total. The stations covered nearly the whole area of the Bering Sea, though they were very widely scattered, a few of them being located out of the Bering Sea.

The position of each hydrographic station was deduced by astronomical sight and made sure by Loran operations if available. Approximate location of the stations together with the track of the ship in the area investigated is illustrated in fig. 9. The exact position by degrees of latitude and longitude with date and time of hydrographic observations including plankton samplings is given in table 1. The hydrographic and biological stations occupied by the "Oshoro Maru" in the present cruise are denoted by adding the symbol "Os" preceding the numeral of the station for distinction from the stations occupied by ships of other institutions which took part in the Norpac Expedition.

The hydrographic casts were made at standard depths in Japan down to 1500 metre depth, once to 2000 metre depth except in the shallow waters in Bristol Bay; the standard depths in Japan are, 0, 10, 25, 50, 75, 100, 150, 200, 300, 400, 500, 600, 800, 1000, 1200, 1500, 2000 metres and deeper. On the "Oshoro Maru" the casts were made by keeping

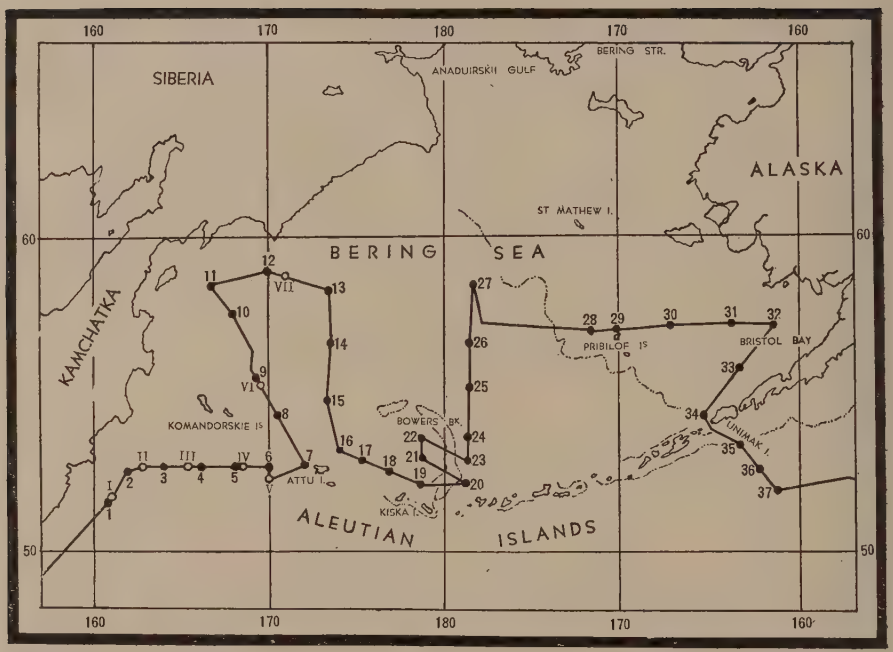

Fig. 9. Approximate location of position of hydrographic stations and gill-net set

● Hydrographic station (1—37)
○ Gill-net set (I—VII)

Nansen bottles and thermometers at these depths as represented by wire length run out irrespective of inclination of wire suspended, *i. e.*, not by vertical distance from the surface. The shallow cast was made by hand winch on the main deck in front of the bridge and the deep cast by elctromotive winch on the upper deck at the stern. Ordinary Nansen bottles, which carried two protected reversing thermometers and one unprotected reversing thermometer, were employed for deep cast. In the shallow cast one or two protected thermometers were provided for each Nansen bottle and the unprotected thermometer was attached only on the deepest Nansen bottle at about 200 metre depth.

The water samples taken with Nansen bottles were employed for chemical analyses of the following matters:

Chlorinity of the samples from every depth at every station;
Dissolved oxygen in the samples from every depth at every station (unsuccessful at St. Os 1, 2 and 4);

Hydrogen-ion concentration of the samples from every depth at every station;
Alkalinity of the samples from every depth at 10 stations (St. Os 2, 4, 6, 8, 9, 11, 12, 13, 15, 27);
Phosphate in the samples from every depth at every station;
Silicate in the samples from every depth at 29 stations (St. Os 1–15, 21, 23, 25, 27–37);
Nitrate in the samples from every depth at 17 stations (St. Os 4–6, 8, 9, 11–14, 21, 23, 27, 30, 32, 35–37);
Suspended matters in the samples from every depth at every station;
Calcium in the samples from every depth at 7 stations (St. Os 2, 4, 6, 8, 10, 11, 13);
Particulate iron in the samples from every depth at 6 stations (St. Os 8, 10, 13, 15, 27, 36);
Total iron in the samples from every depth at 14 stations (St. Os 3, 4, 6, 8, 9, 11, 13, 20, 21, 23, 28, 30, 32, 37).

Dissolved oxygen, hydrogen-ion concentration, alkalinity, phosphate, silicate and calcium were analysed aboard ship immediately after the water was sampled, and the scattering intensity against the suspended matters in the water was also soon measured by means of a nepherometer; samples for nitrate were preserved by adding hydrochloric acid for analysis at the laboratory in the University. For determination of iron, the residue on the molecular filters was dried by expcsing to infra-red lamp and brought to the University.

After returning from the voyage, at the request of Dr. Roger Revelle of the Scripps Institution of Oceanography, a part of the water samples remaining after chlorinity titration, was sent to the United States through the care of the Hydrographic Office for analysis of deuterium. These are samples from the following depths and stations:

St. Os 3: 0, 500, 1000, 1500 m (actually 0, 490, 977, 1455 m)
St. Os 7: 0, 500, 1000, 1500 m (actually 0, 492, 990, 1485 m)
St. Os 12: 0, 500, 1000 m (actually 0, 485, 984 m)
St. Os 19: 0, 600, 1000, 1500 m (actually 0, 443, 735, 1212 m)
St. Os 27: 0, 800, 1500 m (actually 0, 478, 1053 m)

The water samples from the following stations were put at the disposal of Prof. K. Sugawara of Nagoya University for analyses on the iodine, strontium and calcium.

St. Os 3: every depth
St. Os 13: every depth
St. Os 23: every depth
St. Os 37: every depth

For measuring the radio-activity of the sea water a litre of water was dipped from the sea surface at all stations, except St. Os 13 and 27 where the water was sampled from the surface and also from 50 metre depth.

The measurement of turbidity of sea water as it exists in nature was one of the projects in the present cruise. It was expected to find some indication of the nature of the water correlating to the amount of light obstructing substances suspended in the water. At all hydrographic stations a turbidity-meter was let down into the water to a depth of about 100 metres or more by means of cabtyre cord, and the relative value of the turbidity of sea water at various depths was recorded by the meter on the deck.

Plankton net hauls from 150 metre depth (from shallower in Bristol Bay) with a modified "Marutoku Net" were made at every station for estimating the abundance of zooplankton. As it has been experienced that net hauls made at the same place at nearly the same time often yield a considerable variation in amount of zooplankton (Motoda & Anraku, 1955), the net hauls in the present cruise were performed twice at each station; the first haul was made before beginning the hydrographic cast and the second haul after finishing that cast, about one hour and a half to two hours after the first haul.

For collecting the deep sea plankton for the sake of taxonomic interest a coarse mesh net (63 cm in mouth diameter) was once hauled at St. Os 8 by making separate vertical hauls, *viz.*, 2000–1000 m, 1000–500 m and 500–0 m, by means of a throttling mechanism using Discovery type of single release. These hauls were hardly successful; because of the lightness of weight (10 kg), which could not be increased due to the weak electric power of the winch, there occurred many kinks in the steel wire, so that the collection with such a large net had to be abandoned thereafter.

The "Twin Net" was always used for non-divided deep hauls from 1000 or 1500 metre depths once at each and every station on the occasion of the haul of the Nansen bottles. It was hauled together with the deepest Nansen bottle, so that there was no requirement of special time and labour for the haul. The collection yielded only qualitative samples.

A fine mesh net (20 cm in mouth diameter) was hauled twice vertically from about 50 metre depth at every station principally for the purpose of sampling the phytoplankton in the shallow layer. One of the samples thus collected will be used for studies on the distribution of phytoplankton communities, and another one was put for determining the chlorophyll content of phytoplankton. Colorimetric determination by means of phototube colorimeter was made immediately aboard ship. A small fraction of these samples from all of the stations was sent to Prof. H. Okuno of the Kyoto University of Textile Fibers for study on the electron-microscopic fine structures of diatoms.

In the hauls with the "Marutoku Net" and the fine mesh net, a current meter devised by Mr. Z. Nakai was used for recording the distance actually towed. When the ship is drifted by the wind for a certain distance during the operation of vertical haul of the net, the net would be hauled for a longer distance than the actual length of wire run out, so that the volume of plankton sampled would be increased as compared with the case of a haul in calm sea. For correction of this error the current meter was attached at a distance more than one metre above the mouth of the net (fig. 10). The filtration coefficient of the net was not determined because it is known that the current meter which is held at the center of mouth ring of net does not always rotate in exact correspondence to the amount of water filtered by the net; very different counts of the rotation of the current meter are got according to the absolute size of the net (Nishizawa

Fig. 10. Current meter set above the plankton net
C: Current meter

& Anraku, 1956).

More than 330 cc of the surface water were dipped at every hydrographic station and other fourteen positions while underway, but also from 0, 10, 25, 50, 75, 100, 150 and 200 metre depths at St. Os 8, Os 13, Os 23 and Os 27; these samples of water were preserved by adding formalin liquid. They have been put at the disposal of the planktologists in the Hakodate Marine Observatory for direct count of the microplankton.

During the whole cruise plankton samplings were made with the "Handy Underway Plankton Catcher, Model II" at the surface water while underway. The catcher was put out for towing just after starting from each hydrographic station in the Bering Sea, and twice a day in the morning and evening in the other sea areas. Duration of tow was kept to 20 minutes. Sum total of samples amounted to 102; these samples may be used for studies on the distribution of phytoplankton communities covering the whole area traversed.

A fish-larva net was towed at every station just after finishing the hydrographic cast and plankton net haul,and also at sunset covering the whole course of this cruise. The net was towed at the surface layer at a speed as low as about 2 knots for ten minutes keeping the net exposed to the extent of half of mouth ring above the sea surface. The tow was always supervised by Mr. K. Kobayashi. The total number of the sample vials obtained is 70.

Salmon gill-net operations were performed at seven different places in the western region (fig. 9). Only forty-four "Tan" (approximately 1970 metres in length and 5 metres in depth, made of Amilan having 12.5 cm of mesh length when stretched) of the net were used. The gill-net was usually set adrift in the evening and hauled in the early morning. During the set in the sea the net was disconnected from the ship, but watched on the ship by means of Radar which caught the reflection from the corner reflector placed on the buoy on the net (Ishida & Suzuki, 1954).

The fish caught with gill-net mainly comprised chum salmon, *Oncorhynchus keta*, (Shiro-zake), pink salmon, *O. gorbuscha*,(Karafuto-masu) and sockeye salmon, *O. nerka*, (Beni-zake), but sometimes spring salmon, *O. tschawytscha*, (Masunosuke), dolly vardon trout, *Salvelinus malma*, (Oshorokoma) and Atka-mackerel, *Pleurogrammus monopterygius*, (Kitano-hokke) were also captured. The position, date and hour of gill-net set, and the composition of fish species captured are given in table 2. From these specimens of fish usually 20 individuals per species were put to the measurement

of morphometric characters, observation of maturity, sampling of scales for later examination and sampling of stomachs for analysis of content. From a few specimens blood was sampled for biochemical studies of Asst. Prof. T. Kubo.

The diving dredge was twice employed on the shallow bottom in Bristol Bay and a few specimens of sea-stars, shrimps and molluscan shells were obtained. There was not enough time available to make any sufficient test with this dredge.

In the expectation of recording the offshore distribution of sea-birds, porpoises, fur seals, whales and other animals, eye observations at sea were recommended.

VII. Records of Eye Observations of Sea-Birds, Marine Mammals and Other Objects

The recording of eye observations on sea-birds and marine mammals, especially in areas rarely traversed, may be valuable for information regarding the seasonal distribution and migration routes of such creatures in the open ocean, for example, the reports by Moore (1951) are available on the oceanic birds in the western North Atlantic; otherwise only scanty data on the distribution of oceanic animals would be available. Recently J. D. Mac Donald published a report, "A sight record of Steller's albatross: Ibis." in Vol. 94, No. 3 (1952), Report of the World Voyage 1950-52 of H. M. S. Challenger.

In the present cruise every person on the upper deck or on the bridge, who became aware of sea-birds, porpoises, fur seals, whales or other objects in sight at sea, recorded his findings in the field book. Most of the members of the expedition were unaquainted with the birds and other animals inhabiting the open ocean and felt much difficulty in identifying the species of sea-birds flying at considerable distance and of whales by merely looking at their spout or a part of the body exposed above the sea surface for only a short time before they dived. The observations were of course made only haphazardly, not as systematically as, for instance, the observations at definite times on every day; likewise descriptions were often uncertain as to how many and exactly what species of birds or mammals were caught sight of.

Table 3 gives only fragmentary and rather unreliable records, which would scarcely be acceptable to ornithologists or mammalogists, but may include certain trustworthy records which may be useful when collected with data provided by other ships for this area. Mr. Togashi, ship's Purser, is an amateur ornithologist; he contributed many valuable observations on sea-birds. Sometimes he shot birds at sea, and the ship was steered to enable their bodies to be taken from the water for close examination.

Sea-birds and marine mammals observed at sea probably are:

Shearwaters:

Puffinus leucomelas, Streaked shearwater, Ĉ-mizunagi-dori
Puffinus griseus, Sooty shearwater, Haiiro-mizunagi-dori
Puffinus tenuirostris, Slender-billed shearwater, Hashiboso-mizunagi-dori

Storm petrels:
Oceanodroma leucorrhoa leucorrhoa, Leach's fork-tailed petrel, Koshijiro-umitsubame
Oceanodroma furcata, Grey fork-tailed petrel, Haiiro-umitsubame

Auks:
Aethia cristatella, Crested auk, Etorofu-umisuzume
Phaleris pusilla, Least auk, Ko-umisuzume
Synthliboramphus antiquus, Ancient auk, Umisuzume

Guillemots:
Uria columba columba, Pigeon guillemot, Umibato
Uria aalge inornata, Bering Island guillemot, Umigarasu or Roppen-chô

Puffins:
Lunda cirrhata, Tufted puffin, Etopirika or Ororon-chô
Fratercula corniculata, Horned puffin, Tsunome-dori

Skuas:
Stercorarius parasiticus parasiticus, Arctic skua, Kurotôzoku-kamome

Albatrosses:
Diomedea nigripes, Black-footed albatross, Kuroashi-ahôdori

Gulls:
Larus crassirostris, Japanese gull or Black-tailed gull, Umineko
Larus occidentalis, Western gull
Larus schistisagus, Slaty-backed gull, Ôseguro-kamome
Larus argentatus vegae, Vega herring gull, Seguro-kamome

Plovers:

Snipes:

Wild geese:

Wild ducks:

Migrant land birds:
Phylloscopus puscatus puscatus, Brown bush-warbler, Mujisekka

Whales:
Balaenoptera physalus, Common rorqual or Finback, Nagasu-kujira
Balaenoptera musculus, Sulphur bottom or Blue whale, Shironagasu-kujira
Physeter catodon, Sperm whale or Cachalot, Makkô-kujira

Marine mammals other than whales:
Eumetopias jubatus, Northern sea lion, Todo
Callorhinus ursinus, Northern fur seal, Ottosei
Phocaenoides dallii, Northern porpoise, Kita-iruka

On the basis of experience in two preceding cruises in this area, though it is not apparent from table 3, Mr. Togashi is of the opinion that tufted puffins are more common to the south of the Aleutian Islands than to the north, in summer, while the distribution of Bering Island guillemots seems to be the contrary. Slender-billed shearwaters are common in the Kuriles, while sooty shearwaters are common in the Bering sea in summer.

The appearance of storm petrels round a ship is regarded by superstitious mariners as foreboding a storm, and it is said that this is probably because the passage of a ship commonly leaves an area of calmer water in which it is easier for them to obtain food

(Alexander, 1928, p. 76). In the present cruise the appearance of fork-tailed petrels had no particular connection with stormy weather.

Black-footed albatrosses which are a common species in the North Pacific made their appearance when the "Oshoro Maru" sailed for the American coast along latitude 52° N — 48° N after passing out of the Bering Sea. A flock of them were playing around the ship very near, feeding on galley refuse. It is said that albatrosses are generally silent birds, but one day when the purser shot one of them to obtain its skin, the bird that was shot made grunting noises and other birds soon gathered together to escort it. It is a common belief that albatrosses follow a ship day after day for thousands of miles. After the departure from Seattle several individuals, varying in number day by day, of black-footed albatrosses did follow after the "Oshoro Maru" as far as about longitude 180° on August 19, about 2500 miles from Seattle; thereafter they began to fly at a distance from the ship for a few days and then disappeared. Alexander (1928) stated that the personnel of the albatrosses which follow a ship is constantly changing; steadily increased during the day till evening. Kuroda (1933) stated that the number of black-footed albatrosses following the ship was largest from the seventh to the tenth day after departure from Yokohama and that the number of birds was decreased between Honolulu and San Francisco, with increase in bad weather and decrease in calm sea. Such systematic observations in detail on the number of individuals and composition of personnel of albatrosses in sight were not performed on the present cruise.

Very lovely white gulls (western gull ?) followed the ship from Seattle. They often rested on the hand rail on the deck, without timidness for approaching man, but soon, on the third day after departure, they started back to their home land.

Northern fur seals and sometimes northern sea lions were coming near to the ship when the gill-net was hauled, to devour the salmon entangled in the net. While underway members of the staff were sometimes able to see them, especially often off the Pribilof Islands and in and the southern portion of Unimak Pass.

Acknowledgement

In behalf of all of the members participating in the present research cruise, the writers wish to express sincere gratitude to the staff of the University who have supported them from the beginning of the plan and encouraged them thereafter through the entire course of investigations. They deeply thank Dr. Y. Takenouti, Director of the Hakodate Marine Observatory, Ministry of Transportation, and Asst. Prof. H. Kotô, Asst. Prof. S. Mishima, the former Captain of the "Oshoro Maru", and Instructor S. Nishizawa of the University for their kindness in giving valuable advices as decisions were being made regarding the course of the cruise in the Bering Sea.

Thanks are also due to the Hydrographic Office, Maritime Safety Board, Ministry

Table 1. Position, date and hour of hydrographic observations and plankton samplings and depth of cast

No. of station	Ship's time		Greenwich time		Latitude	Longitude	Depth of sea bottom determined by echo-sounding (m)	Maximum depth of observation (m)
	Date	Hour	Date	Hour				
Os 1	June 26	1920~2130	June 26	0920~1130	51°—43′N	160°—30′ E	——	1440
Os 2	27	1423~1630	27	0423~0630	52°—52′N	161°—50′ E	——	1270
Os 3	28	1045~1300	28	0045~0300	53°—00′N	164°—00′ E	——	1455
Os 4	29	0724~0917	28	2024~2217	53°—01′N	166°—00′ E	——	1447
Os 5	29	1723~1927	29	0623~0827	53°—00′N	168°—00′ E	——	1431
Os 6	30	1352~1530	30	0252~0430	53°—02′N	170°—00′ E	——	1482
Os 7	July 1	1400~1530	July 1	0300~0430	53°—02′N	172°—00′ E	——	1485
Os 8	2	0330~0710	1	1630~2010	54°—30′N	170°—33′ E	——	1989
Os 9	3	0535~0830	2	1835~2130	55°—58′N	169°—11′ E	——	1239
Os 10	4	0930~1106	3~4	2230~0006	57°—41′N	167°—59′ E	——	1456
Os 11	4	1910~2050	4	0810~0950	58°—29′N	166°—32′ E	——	1321
Os 12	5	1405~1525	5	0305~0425	59°—00′N	170°—00′ E	1150	984
Os 13	6	1230~1605	6	0130~0505	58°—30′N	173°—15′ E	——	1460
Os 14	7	0540~0705	6	1840~2005	56°—54′N	173°—17′ E	——	1403
Os 15	7	1937~2102	7	0837~1002	55°—10′N	173°—17′ E	——	1400
Os 16	8	0930~1103	7~8	2230~0003	53°—25′N	173°—38′ E	——	1338
Os 17	8	1720~1848	8	0620~0748	53°—10′N	175°—04′ E	——	1353
Os 18	9	0250~0434	8	1550~1734	52°—50′N	176°—56′ E	——	1331
Os 19	9	1210~1310	9	0110~0210	52°—28′N	178°—40′ E	——	1212
Os 20	9~10	2335~0155	9	1135~1355	52°—30′N	178°—54′ W	——	1205
Os 21	10	1655~1913	10	0455~0713	53°—14′N	178°—40′ E	——	1428
Os 22	10′	0020~0138	10	1220~1338	53°—54′N	178°—40′ E	——	1387
Os 23	10′	1220~1353	11	0020~0153	53°—03′N	178°—52′ W	——	1465
Os 24	10′	1920~2100	11	0720~0900	53°—50′N	178°—52′ W	——	1474
Os 25	11	0830~0952	11	2030~2152	55°—34′N	178°—48′ W	——	1329
Os 26	11	1915~2042	12	0715~0842	57°—00′N	178°—58′ W	——	1466
Os 27	12	0810~1115	12	2010~2315	58°—49′N	178°—43′ W	——	1053
Os 28	14	1005~1030	14	2205~2230	57°—16′N	171°—50′ W	105	95
Os 29	14	1645~1705	15	0445~0505	57°—27′N	170°—11′ W	62	50
Os 30	15	0520~0535	15	1720~1735	57°—26′N	167°—05′ W	65	50
Os 31	15	1750~1815	16	0550~0615	57°—23′N	163°—58′ W	59	50
Os 32	16	0500~0600	16	1600~1700	57°—16′N	161°—40′ W	54	50
Os 33	19	1945~2015	20	0645~0715	56°—04′N	163°—15′ W	82	75
Os 34	20	0940~1015	20	2040~2115	54°—46′N	165°—19′ W	170	147
Os 35	20	2220~2350	21	0920~1050	53°—40′N	163°—31′ W	1630	1482
Os 36	21	0625~0800	21	1725~1900	52°—58′N	162°—19′ W	——	1470
Os 37	21	1430~1620	22	0130~0320	52°—15′N	161°—09′ W	——	1492

Table 2. Position, date and hour of gill-net set and number of fish captured

No. of gill-net set	Position	Date and hour in ship's time		Nuber of individuals of fish captured					
		Net set	Net haul	Chum salmon	Pink salmon	Sockeye salmon	Spring salmon	Dolly vardon trout	Atka-mackerel
F 1	51-43N 160-31E	June 26 1851	June 27 0421	65	14	11	0	4	0
F 2	52-56N 162-28E	27 1951	28 0446	79	85	27	0	1	0
F 3	53-01N 165-14E	28 1921	29 0441	101	43	98	1	0	0
F 4	53-02N 168-00E	29 1954	30 0510	96	37	41	1	0	5
F 5	52-39N 170-00E	30 1921	July 1 0517	71	40	18	0	0	0
F 6	55-51N 169-10E	July 2 1925	3 0507	27	70	41	0	0	0
F 7	58-49N 171-12E	5 2042	6 0434	83	125	2	2	22	0

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濾水計によるプランクトンネット濾水量の測定について*

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A Note on Measuring of the Volume of Water Filtered by Plankton Net by Means of a Flow Meter

Satoshi NISHIZAWA and Masateru ANRAKU

Abstract

The variability of catches in successive zooplankton samples has come to attract the sincere attentions of many workers. The variation in a single observation ranges generally 30 to 100%. Such variability may arise (a) from the manner in which the population is unhomogeneously distributed or (b) from variation inherent in the method of sampling. Under (b) are included such factors as variations in the speed of haul, deviations of the haul from the vertical, completeness of the washing of the net, etc. Winsor and Walford (1936) examined the variability arising from factors under (b) and concluded that a limit to the precision of estimate is set by the relative variability of the volume sampled. Barnes (1949a) studied the variability in paired plankton hauls, finding that the variation observed is largely dependent upon variation in the volume of water filtered by the net. In recent years, the cause of such a variation has come to be ascribed mainly to the local swarming of the plankton population itself (Barnes, 1949b; Barnes & Marshall, 1951; Anraku, unpublished). The variation due to volume of water filtered, however, can not be considered as negligibly small.

Such volume is commonly measured by some type of flow meter; the flow meter designed by Mr. Z. Nakai has generally been used by Japanese workers for this purpose. The writers experimented with this type of flow meter to find its characteristics and the disturbance of the stream lines of water near the mouth of the net during the haul.

Firstly, four flow meters of this type (No. 61, 65, 101 & 102) were towed horizontally in the tank (1×1×9m) (Fig. 1) respectively, without being attached to any net, ring or such an obstacle in front of the meters as bridles. Secondly, each meter was attached at the center of the iron ring just the same as the mouth ring of a plankton net and towed without bridles; two kinds of rings were adopted, that is, 20 cm inner dia. and 45 cm inner dia. Lastly, four different types of plankton nets having the same mesh of cloth were towed successively. In the latter two series of tow the same net or ring for the different flow meters was used one by one. Experimental tow for any net or ring and again for any flow meter was made, and towing speed was changed to five grades from 25 cm/s to 130 cm/s for tow of particular net with particular flow meter. Again the tow at particular speed was repeated ten times. Thus the total experimental tows in tank amounted 1200. The results of these experiments are represented in Figs. 2, 3 and 4.

In the first experiment with flow meter alone it was determined that the rotations of the rotor in tow for a distance of 10 meters were not independent of the hauling velocity; three out of the four flow meters showed increasing values of rotation with increasing speed when the velocity remained below 100 cm/s, whilst above this speed, the rotations reaches almost stable values. However, the velocity at which the rotation became stable indicating fair correspondence to the distance, varied with the individuality of the flow meters. The static resistance of rotor

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may be the main cause of the inconstancy of rotation at low speed. Only one (No. 101) of the four flow meters was shown to keep almost constant rotation irrespective of the hauling speed. When the flow meter was towed with ring alone in the second experiment, the rotation at any hauling speed was increased a few per cent above the values obtained in towing of flow meter alone. When the flow meters were attached to center of mouth ring of the long net (20 cm in mouth dia. and 80 cm in side length), the rotation was increased over the values when towed with ring alone. However, in the case of short net (40 cm in side length with the same mouth dia.) the values were rather lower than those obtained in towing of flow meter alone, on account of the insufficient filtration. Such rise in rotation is considered to be mainly due to the increase of water velocity at the mouth of nets which has resulted from the contraction of the flux of stream lines passing through the mouth of the net or ring alone. The stream lines at the mouth were photographed (Fig. 5). The water flow for pitch circle of the ring, not for inner circle, is theoretically constant irrespective of presence of the ring. Exactly, the volume of water which passed through the ring per unit time is given by the hauling velocity times the area of pitch circles of the ring, not of the inner circle.

Insufficient filtration represented by short net reduces the rotation of the flow meter especially at low hauling speed below 100 cm/s. However, at high speed above 100 cm/s the rotation tends to converge to a certain value irrespective of length of net.

It was found that some flow meters showed irregular rotations against a fixed velocity of tow, so that one must be aware that the water to enter the net is considerably retarded by the existence of the flow meter especially when he uses one of ill manufacture; a poorly made flow meter is really useless. The experiments yielded the estimates of variation of velocity as high as 20 % for coarse machine (Tables 2 and 3).

The radial distributions of velocity of water covering whole area of the mouth of 45 cm nets (45 cm × 100 cm net and 45 cm × 165 cm net) were roughly determined at sea by comparing the rotations of flow meter held at the periphery of the mouth with those of a meter fixed at the center of the mouth (Table 4). In the case of the short net (45 cm × 100 cm net), the velocity at the center was higher by 10 % than that at the periphery at the hauling speed of about 100 cm/s, while at the hauling speed of about 80 cm/s the relation was the contrary. In the case of the long net (45 cm × 165 cm net), however, the speed at the center was always 20 to 30% lower than that at the periphery throughout the hauling speeds 90 to 130 cm/s. Such radial distribution of velocity of water flow at the mouth of the net should be taken into consideration when the flow meter is used to measure the inflow of water into the net.

The writers observed and photographed from the window of the Undersea Observation Chamber "Kuroshio" in the subsurface that, when the net was suddenly stopped during haul there happened an ejection of water from the inside of the net (Fig. 7). Sudden change of hauling velocity may also have some effect, especially for the net of insufficient filtration.

プランクトンネットの同一場所に於ける繰返しの曳網毎の採集量には著しい変動のある事が注目され，元田・安楽（1955）の実験に於ては採集量が変動係数 40～200% の範囲で変動した。極めて限られた地域に於てネットを繰返し水平に曳行しても採集量に50%内外の変動係数が見られる（Winsor & Clarke, 1940; Barnes, 1951; Prasad *et. al.*, 1952）。斜曳網（Oblique haul）の場合はやゝ変動が少い様であるけれども25%内外の変動係数は現れる（Winsor & Clarke, 1940）。

これらの変動が何に起因するかについては a) 採集操作の技術的な不均一と b) プランクトン母集団自身の分布型が必ずしも機械的に無作為でない事の何れか，又は双方に原因が求められなければならない。この内技術的な原因として考えられるものには，曳網して資料を標本瓶に採取する迄の操作の間に起る誤差と，それを実験室に持帰つて後定量又は検鏡計数する迄のすべての操作の間に起る誤差とがあるが，後者は相当の注意を払う事によつて僅少な程度に止める事が出来るであろう。然し前者特に曳網操作そのものには可成り

変動の原因となる要因が含まれていよう。元田・安楽（1955）は㊗ネット（口径45cm，側長100cm）を用いての一連の垂直曳網に於て曳網速度を比較的高く（100 cm/sec以上）保つ場合には割合に少い採集量の変動を示す傾向がある事を指摘したが，各回曳網速度の差及び同一曳網中の速度の不定は少からぬ変動の原因となる事は想像に難くない。曳網速度が採集量の変動に与える影響は網の形態，その仕立，使用する篩絹の種類（従つて clogging の程度）等によつてネットに流入する海水の流線を変化させ，結局ネット総体の濾水量を変動させるからである。

採集量変動の原因の一半はこの濾水量変動にあるとの推測は行われた（Winsor & Walford, 1936; Barnes, 1949a）。元田・安楽（1955）は濾水計をネット口部に付けて濾水量を測定し，採集量をその濾水量で割つた値に就いて変動を調べたが変動値は濾水量による補正をしない場合よりも必ずしも低くない事を経験した。一方 Barnes (1949b), Barnes & Marshall (1951) 及び安楽（未発表）はポンプ採集による採集量変動が，主として濾水量の変動に基くものではなくて，母集団自身の non-random な分布によるとする考えに傾いている。然しネット採集に関する限り採集操作の点から濾水量の曳網毎の変動は決して少くないと思われる。そこでネットの濾水量を知る事が必要となり，近来大きなネットの口部中央にプロペラ式濾水計をつけてネットの濾水量を測る様になつて来た。従つて濾水計の諸特性についての考察が問題となつて来る。

筆者等は東海区水産研究所中井甚二郎氏の考案したプランクトンネット用の濾水計（鶴見製作所製品）を用い実験水槽及び海中に於て若干の実験を試みたのでその結果を報告する。

I 濾水計の速度-回転数特性

濾水計の速度特性を調べる為に4個の濾水計（製品番号61，65，101及び102）を使つて長さ9mの実験水槽内で水平曳行を行つた（Fig. 1）。曳行はモーターによつて駆動し速度を 20～130cm/s の範囲で任意に変えて実験した。各曳行は夫々10回ずつ繰返し行い，その平均値をとつて曳行速度と濾水計回転数とを記録した。繰返し10回曳行した測定値は極めて分散が少く曳行速度，回転数とも変動係数は高々2％である。

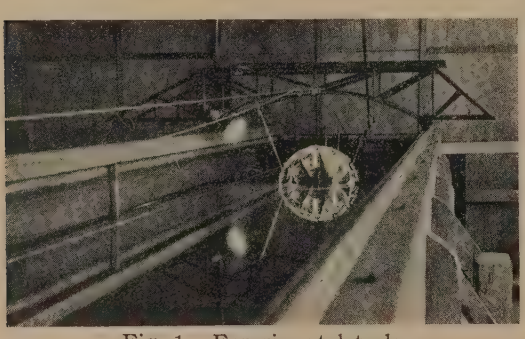

Fig. 1. Experimental tank

先ず各濾水計について濾水計のみを水槽の移動架台に連結し，濾水計前方には如何なる障害物もない状態で曳行した。4個の濾水計のうち No. 61 と No. 101 の結果を Fig. 2-Aの曲線に示す。横軸は曳網速度縦軸は曳網距離 10m に換算した回転数である。他の濾水計ではこの2つの中間の曲線が得られた。更に縦軸を毎秒毎の回転数に換算した曲線を Fig. 2-B に示す。

両図を概観すると2つの濾水計の間に著しい差のある事が分る。No. 101 では毎秒の回転数が流速と殆んど直線関係を持つていて，従つて10m曳行間の回転数は大体横軸と平行に走つて流速にかゝわらず略一定である。然し詳しく見ると僅に高速側の回転数の上昇が低速側より急である。之に反し No. 61 では低速側及び高速側で毎秒の回転数が低く中速度（60～70cm/s）で No. 101 と略同数の回転を示して居る為に，10m曳行間の回転数は低速側で著しく落ち，高速側でもやゝ落ちている。

Fig. 2-B の曲線を低速側に外挿して横軸との交点を求めその値を threshold velocity として各濾水計について求めると Table 1 の如くなる。Threshold velocity の大小は軸受回転部の静止摩擦抵抗の大小によるものであるが，これの大きなものは後に見る様に決定的な特性を持つことになる。

次にこの濾水計をネット用の鉄製リングの中心に3本の紐をはつてとりつけ，リングの前方には曳綱など

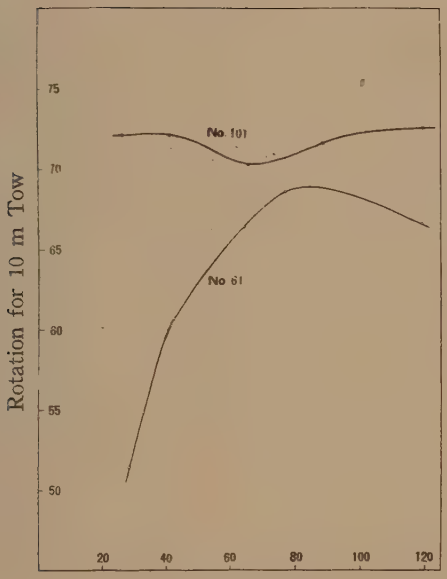

Fig. 2–A. Relation between the hauling speed and the rotation of the flow meter for 10 m tow when flow meter was towed alone
Solid circles: flow meter No. 101; circles: flow meter No. 61

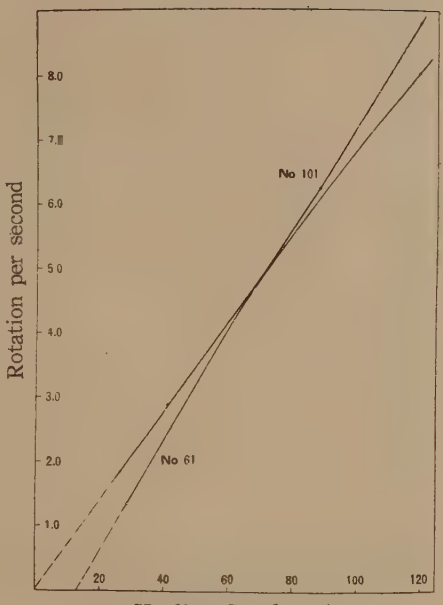

Fig. 2–B. Relation between the hauling speed and the rotation of the flow meter per second when each was towed alone
Solid circles: flow meter No. 101; circles: flow meter No. 61; chain lines show extrapolated values at low speed.

Table 1. The threshold speeds in which rotor of flow meter begins to rotate.

	No. 61	No. 65	No.101	No.102
Threshold velocity	12.5cm/s	4.0cm/s	0.0cm/s	5.0cm/s

一切の障害物をおかず曳行した。Fig. 3–A のb，c 曲線は夫々内径45cmリング，20cmリングをつけた場合の回転数の変化を示してある。図中 a の曲線は Fig. 2 の濾水計のみを曳行した場合の値を比較の為に挿入したものである。何れの濾水計にも共通なことは，濾水計のみを曳行した場合よりもリングをつけた場合の方が総べての速度に於いて回転数が僅かずつ多いということと，大体の傾向は a 曲線の場合と極めてよく似ている事である。之はリングをとりつける事によつて流線がそこで絞られる結果，必然流速が上るものであろう。この場合にも縦軸に毎秒の回転数をとつて曲線を引き，リングなしで濾水計のみを曳いた場合と比べて見ると（Fig. 3–B）増速の程度は最高 5 cm/s 程度，平均して 2 cm/s 位で，高速度になる程多少増加するも

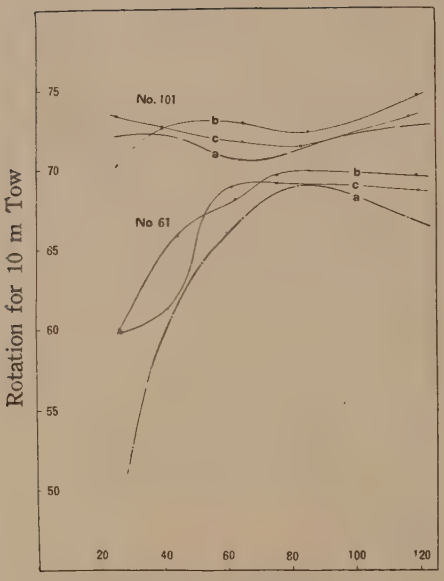

Fig. 3-A. Relation between the hauling speed and the rotation of the flow meter for 10 m tow when flow meter was towed being attached to the rings
Solid circles (b): 45 cm dia. ring; circles (c): 20 cm dia. ring; the chain lines (a) are quite identical with those in Fig. 2-A.

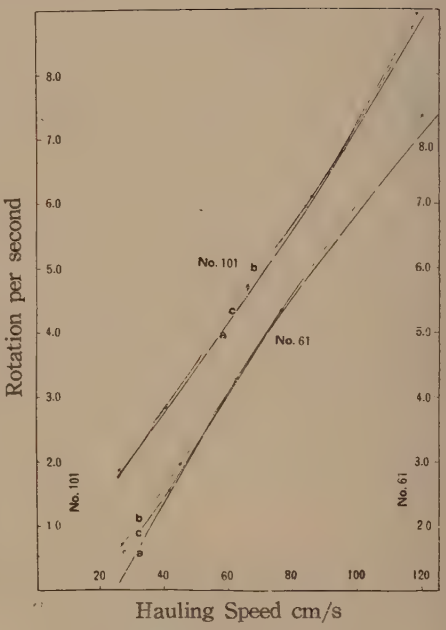

Fig. 3-B. Relation between the hauling speed and the rotation of the flow meter per second when flow meter was towed being attached to the ring
Solid circles (b): 45 cm dia. ring; circles (c): 20 cm dia. ring; the chain lines (a) are quite identical with those in Fig. 2-B.

の（No. 101），速度に無関係のもの（No. 65, No. 102），中速で殆んど増速* せずそれより低速になる程，又高速になる程増加するもの（No. 61）等がある。リングの大小による差は明かには現れなかつた。

この様にリングをつける事により，中心部の水の流速が増加することは確かであるが，リングの鉄棒中心線が作る仮想の円（pitch circle）を通過する流量か，之によつてそれだけ増加した事を意味せず，リングの鉄棒の占める部分を水の流線が避ける為に起るものと思われる。

次にネット（篩絹GG56製）をつけて，やはり前方には曳綱をつけずに曳行を試みた。ネットは口径20cm，側長80cmと口径20cm，側長40cm及び口径45cm，側長100cmの3種を用い，その結果は Fig. 4 に示してある。Fig. 4-A, -B_1 は濾水計 No. 101，Fig. 4-A_2, -B_2 は No. 61 の場合で，曲線 d, e 及び f は夫々20cm×80cm，20cm×40cm及び45cm×100cmのネットを曳行した場合である。

先ず口径20cm，側長80cm のネットについて見ると，曲線の傾向は無網の場合とよく似ていて，回転数の

* リングをつけて速度 v で曳行して毎秒 n 回転したとすれば，n に相当する曳速 v′を a 曲線から求め，v′−v を増速量とした。

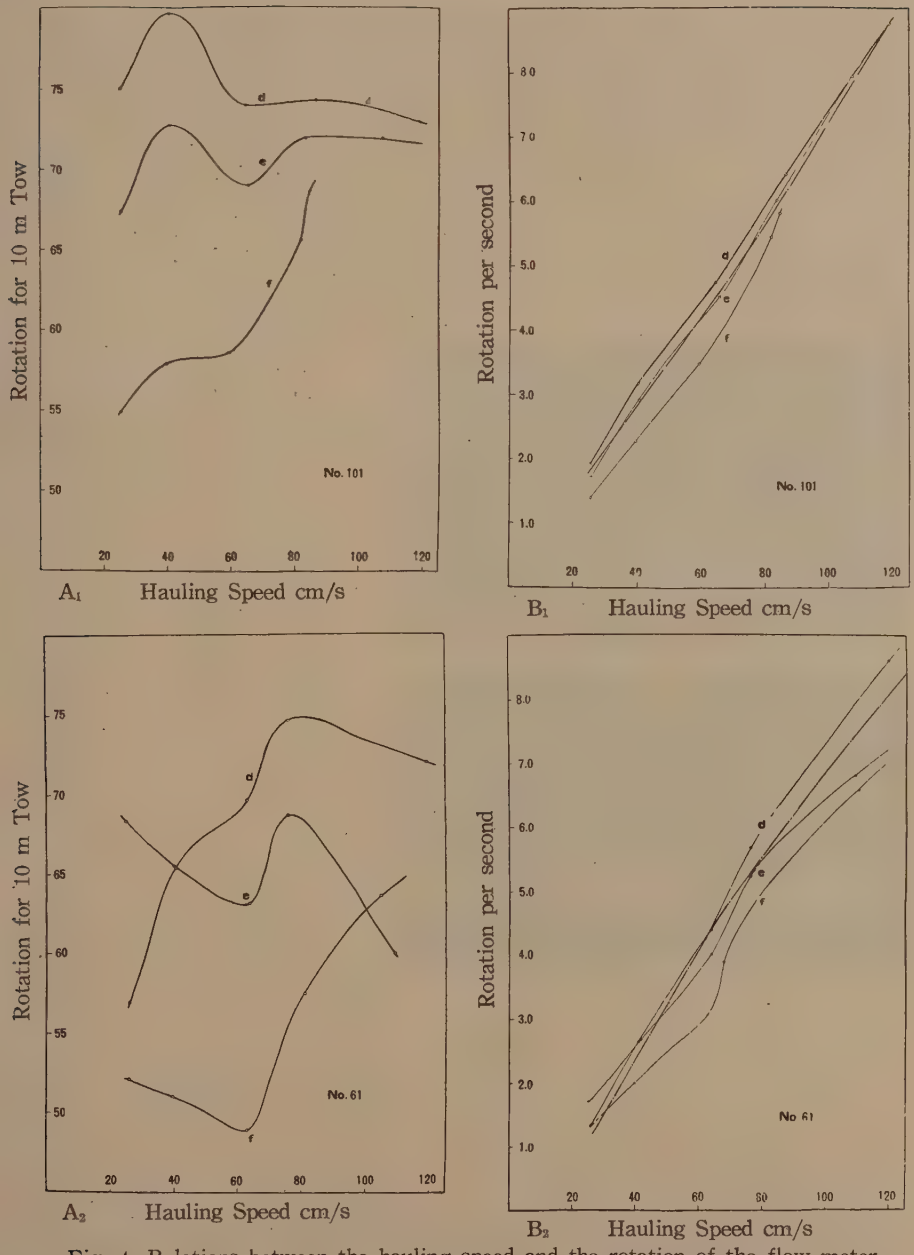

Fig. 4. Relations between the hauling speed and the rotation of the flow meter for 10 m tow (A_1, A_2) and between the hauling speed and the rotation per second (B_1, B_2) A_1–B_1: flow meter No. 101; A_2–B_2: flow meter No. 61; d: 20 cm × 80 cm net; e: 20cm × 40cm net; f: 45cm × 100cm net

極大及び極小はa曲線と同じ速度で起つている。唯何れの濾水計に於ても，無網の場合より回転数が遙に高く，リングをつけた場合よりも高くなつている。その増速の程度を先の様にして求めると，濾水計のみを曳行した場合に比べて最高8 cm/s，平均5 cm/s 程度である。然も threshold velocity の小さい No. 101 では，速度が上ると共に増速量は少くなり，120cm/s 位でほゞ濾水計のみ曳行した場合の値に落着く。

ネットをつける事によつて口の中心部の流速が更に増加するのは，恐らくネット の存在によつて流線が更に絞られる結果であろう。殊に簡絹をリングにとりつけるカンバスの部分の影響が大きいと思われる。高速に於けるやゝ急激な回転数の低下は，次第に網地の濾水抵抗の利き始めている事を示している。Fig. 5 に口の部分に於ける流線の模様を写真によつて示した。之はネットを半分だけ水面上に露出して曳行しつゝ写したものである。Fig. 5-A は 20cm×40cm ネット，Fig. 5-B は 45cm×100cm ネットの 場合で曳行速度は何れも 50cm/s である。

Fig. 5. Photographs showing the stream lines at the mouths of the nets
(A) 20 cm×40cm net; (B) 45cm×100cm net. The net was so fixed that the lower half of the nets was dipped in water and towed at the velocity of 50 cm/s. Camera was in motion at same speed and caught the stream lines represented by alminium powder on the surface.

同一口径で側長 40cm（前回の半分）のネットをつけて曳行すると，濾水計 No.61（No. 65 も同様）では，低速で著しく回転数が高く出る（Fig. 4-A_2）。ネットの形態が短くなつた為に，絞りの影響が更に著しくなつた事を示す。然し速度の上昇と共に回転数は無網の場合よりも落ちてしまう。そしてその後の 60～70cm/s 即ち回転特性のよい所で，急激に回転数が上るが，無網の場合をこえることはない。一方濾水計 No. 101（No. 102 も同様）では，最低速でやゝ回転数が落ちるが，それ以上の速度では大体無網の場合とよく一致した曲線を作る（Fig. 4-A_1）。100cm/s以上の速度では濾水計 No. 101は a, b, c, d の曲線と共に一定回転数に収斂して，100～120cm の速度では2％内外の精度でよく一致する。然し濾水計 No. 61 は高速になる程回転数は遙に低下してしまう。

今 20cm×40cm ネットついて各曳網速度に於ける濾水計回転数から既に述べた方法によつて，ネット口部に於ける流速を推定して見ると Table 2 の如くなる。傾向は必ずしも一定していないけれども，速度が高くなると口部の流速が曳行速度に遅れる。濾水抵抗による減速と絞りによる増速とは，60～80cm/s の間で釣合う様である。No. 101 では高速側でも増速しているが，之は既に述べた様にこの濾水計が高速側で速度特性がやゝよくなつている為に，絞りによる増速が濾水抵抗による減速にやゝ打勝つていることを示すものであろう。

ところで同一ネットを同一速度で曳行して，上表の様に口に於ける流速が便用する濾水計によつて相違す

Table 2. The estimated speeds of inflow of water at the center of the mouth of 20cm×80cm net when towed with each of four flow meter

	30cm/s	40cm/s	50cm/s	60cm/s	70cm/s	80cm/s	90cm/s	100cm/s	110cm/s
No. 61	36 (+6)	43 (+3)	49 (−1)	56 (−4)	67 (−3)	79 (−1)	88 (−2)	94 (−6)	99 (−11)
No. 65	33 (+3)	43 (+3)	53 (+3)	64 (+4)	72 (+2)	78 (−2)	85 (−5)	92 (−8)	99 (−11)
No. 101	29 (−1)	41 (+1)	51 (+1)	59 (−1)	70 (0)	81 (+1)	92 (+2)	102 (+2)	111 (+1)
No. 102	30 (0)	41 (+1)	51 (+1)	60 (0)	69 (−1)	79 (−1)	89 (−1)	98 (−2)	109 (−1)

ると言うことは，濾水計そのもの、存在が口に於ける流速に影響を与える事を示している。絞りによる増速は上述の様に，流量の増大を意味するものとは考えられないが，濾水抵抗及び濾水計による減速は流量を減少させるものと考えなければならない。

最後に口径 45cm，側長 100cm のネット（通称参ネット）を曳行してみた。上記の場合に比し低速側で甚だしく回転数が落ちる。然し 4 つの濾水計の何れの場合にも，高速に於て極めて急激に回転数の上昇を来し，a の曲線に収斂しようとする傾向がある。

各濾水計を使用した場合の口に於ける流速の推定値は Table 3 の様になる。No. 101 及び No. 65 は高速になる程次第に流速の遅れを挽回して行くが，No. 61 及び No. 102 では却つて遅れが増大して行く傾向にある。前者は高速側の特性のよいものであり，後者はよくないものである。此のことは濾水計の特性そのものがその部分の流速に影響する事を示している。ところで 20cm×40cm ネットと 45cm×100cm のネットとでは口の面積と濾水面積との比は夫々 $\frac{1}{4}$ 及び $\frac{1}{4.45}$ で，濾水能力は後者の方がむしろよいと考えられるにも拘らず，一般に甚しく濾水計の回転数が落ちるのは，恐らく口径が大きい為に絞りの効果か口の中心の流線に迄達しないことに依るものと思われる。従つてこの場合に，ネットの入口では中心からの距離によつて流速の大きさに変化があるであろう事が推測される。

Table 3. The estimated speeds of inflow of water at the center of the mouth of 45cm×100cm net when towed with each of four flow meters

	30cm/s	40cm/s	50cm/s	60cm/s	70cm/s	80cm/s	90cm/s	100cm/s	110cm/s
No. 61	31 (+1)	36 (−4)	41 (−9)	47 (−13)	61 (−9)	71 (−9)	81 (−9)	88 (−12)	98 (−12)
No. 65	26 (−4)	36 (−4)	44 (−6)	51 (−9)	61 (−9)	73 (−7)	85 (−5)	98 (−2)	—
No. 101	24 (−6)	33 (−7)	42 (−8)	50 (−10)	61 (−9)	75 (−5)	—	—	—
No. 102	25 (−5)	35 (−5)	44 (−6)	53 (−7)	62 (−8)	71 (−9)	81 (−9)	—	—

Ⅱ ネット口部に於ける流速分布

ネットの口部に於ける流速の観察は主として海上に於て行つた。標準㋮ネット 2 個を Fig. 6 の様に水平な鉄棒（長さ 85cm）の両端に下げて同時に曳行した。同様の実験を延長㋮ネットについても繰返した。濾水

Fig. 6. Plankton nets with flow meters

計は No. 61 及び No. 65 を用い一方を一つのネットの口輪の中心に他方を他のネットの口輪の端に固定し 9 回繰返し垂直に曳上げた。次に濾水計の位置を交替し（一つのネットの口輪の中心のものを他のネットの口輪の端に，他の端のものを別のネットの中心に移し）5 回繰返し曳上げた。曳上深度は20mとし，曳網は電動測深儀により速度は出来るだけ一様になるように注意した。その結果を Table 4 に示す。

Table 4. Comparison of the velocity of water inflow at the center of the mouth with that at the periphery
The numbers in brackets indicate the range of variation.

Net	Flow Meter		No. 65 at the center No. 61 at the periphery	No. 61 at the center No. 65 at the periphery	No. 101	No. 102
	Towing Speed		99cm/s(95～102)	99cm/s(95～104)	85cm/s	70cm/s
45cm × 100cm	Water Speed at the center	Rotation	112 (100～120)	109 (92～113)		
		Speed	80cm/s	78cm/s	84cm/s	70cm/s
	Water Speed at the periphery	Rotation	102 (94～108)	106 (95～110)		
		Speed	71cm/s	72cm/s	86cm/s	79cm/s

Net	Flow Meter		No. 65 at the center No. 61 at the periphery		No. 61 at the center No. 65 at the periphery	
	Towing Speed		93cm/s (91～97)	139cm/s (130～148)	90cm/s (89～91)	122cm/s (108～134)
45cm × 165cm	Water Speed at the center	Rotation	94 (91～102)	96 (89～99)	95 (89～108)	90 (87～95)
		Speed	85cm/s	128cm/s	82cm/s	107cm/s
	Water Speed at the periphery	Rotation	121 (110～138)	118 (116～123)	122 (108～150)	117 (113～122)
		Speed	109cm/s	156cm/s	106cm/s	136cm/s

表中括弧内は値の変動範囲を示す。中心及び端に於ける速度は，前と同様濾水計のみを曳行してその回転数を示すときの曳行速度を入れたものである。標準㊙ネットについては濾水計 No. 101，102 を用い，水槽内で濾水計を口の端に固定して曳行し 2 組の値を得た。Table 4 の右端の 2 列はその結果を示している。上表から明らかな様に標準㊙ネット 45cm×100cm では，低速側では中心より端が速く，高速側では逆に中心が端より速くなつていて，その交替は大体曳行速度 80～90cm/s の間で起つていることが分る。然るに一方延長㊙ネット（45cm×165cm）では，大体同範囲の曳網速度で常に端の方が中心より早くなつている。ネットの形より考えて短いネット程，口に於ける流線の絞りは甚しく，標準型の様なネットでは，速度が早くな

Fig. 7. Photographs showing the ejection of the water from inside of the net when the vertical haul was suddenly stopped

Towing speed was 30 cm/s. The photographs were taken from the window of Undersea Observation Chamber "Kuroshio". (A) 45cm × 100cm net, at the time 1.5 second after sudden stop. A small bag of gauze containing finely powdered potassium permanganate was fixed inside the net at a position 35 cm from the mouth. (B) Model net (8cm × 30cm), during haul without sudden stop. (C) Same net, at the time of sudden stop of the net. In this case a gauze bag of potassium permanganate was fixed above the mouth at the knot of the bridles.

る程中心部の流線は大きく絞られ，一方端の部分は水とネットとの摩擦が大きく利いて遂には中心部より遅くなるであろう。

尚上表で注意すべき事は，現場に於ける濾水計回転数の著しい変動である。技術的に止むを得ない曳網速度の変動が高々10%内外（多くは5%内外）であるのに，濾水計回転数の変動は20%或はそれ以上にも達する。一方水槽実験に於ける経験では，極めて斉一な回転数が得られるのであるから，この様な現場に於ける変動は，水中に於ける何等かの海水の不規則な変動や船の動揺によつて起るものと考えなければならない。尤も曳網速度の微細な変動も，既に述べた様に多くの濾水計が速度による特性を持つている以上，決して無視し得ないものである。

潜水探測機くろしお号の窓前に2つのネットを固定し，各々に濾水計をつけてくろしお号と共に垂直に浮上させて潜水機内から窓を通して観察を試みると，浮上速度が略一定（3cm/s）であるにも拘らず，2つの濾水計の回転状態は極めて不規則で，屢々一方が回転していても他方は回転を停止していたりする。潜水機の周囲に於ける海水の撹乱がこの様な不規則な回転を引起すと思われる。

Ⅲ 曳網速度の急変によるネット内の水の溢出

ネットを水平或は垂直に曳網した場合に，曳網速度に急変が起る場合，特に急停止した様な場合には，ネット内の水がネットの口から一部分溢出する可能性のあることは容易に推測出来ることで，既に Barnes (1949a) は区分採集に際しネットを閉じる時，使錘が閉鎖装置にあたつてからネットの口が閉る迄の数秒間ネットの停止する期間があることを確め，その際ネット内の水がその内容物を伴つて口部から溢出することを水槽実験によつて示した。我々は潜水探測機くろしお号の窓前に各ネットを固定しネットの内部，口から35cm下つた所に，過マンガン酸加里の微細粉末を包んだガーゼの袋を固定して，くろしお号と共に垂直に上昇しくろしお号を停止させる事によつて実際に内容水の溢出する様を観察した。Fig. 7-A はその写真を示す。くろしお号の上昇速度は大凡 30cm/s である。停止後過マンガン酸加里の溢出が起る迄に約 1.5秒を要した。更に模型ネット（8 cm×30cm）を用いて同様の観察を行つたが，この際は過マンガン酸加里を入れた袋を Fig. 7-B, -C の様にネットの上部に固定した。この場合には停止すると殆んど同時に烈しく過マンガン酸加里の紫色の煙が上方に立昇つて，その部分で水が上昇運動する事を示している。

この様な現象は濾水能率の悪いネット程，又曳網速度の大きい場合程起り易いことは容易に推察され，その様な場合にはネットが停止しなくとも，急に曳網速度が変る様な場合には，多少ともこの溢出があるものと考えねばならないであろう。

Ⅳ 結　　語

濾水計はその使用目的から言つて，一定距離を曳網した場合，曳網速度に無関係に一定した回転数を示すことが望ましい。この様な場合には曳行中の速度変化に拘らず，我々は濾水計の読みによつて濾水量を定めることが出来る。然しながら一般には Fig. 2, 3, 4 等に示した様に，曳網距離が一定でも曳網速度によつて回転数は著しく変動するばかりでなく，ネット形状如何によつても変動する。従つて曳網速度に10%内外の変動が避けられない限り，濾水計の読みによつて知られる流量には著しい精度の制限がある。濾水計の読みの変動が流量の変動によるものか，曳網速度の変動によるものか一定め難いからである。たゝ例えば No.101 の様に比較的特性のよい濾水計を使用した場合には曳網速度に多少の変化があつても，濾水計の読みによつて略正確な流量を定め得ると思われる。然しながらその場合にも形状の異るネットを使うならば，夫々各ネット毎に速度回転数特性を予め求めておかなくては正確を期し難い。

更に流入口に於ける速度の分布の不均等なことによつて，中心に於て測られた流量から全流入量を算定したのでは，必ずしも正しい値を与えない。事実標準㊱ネット（45cm×100cm）では 100cm/s の曳行速度で中

心と端とで10%の差があり延長稚ネット（45cm×165cm）では30%の差がある。これは濾水計の読みの変動による誤差よりも大きな誤差を流量に与えるであろう。そしてこの流速分布の不均一からくる誤差を補正するのには，更に精密な測定を水槽内で行う必要がある。

曳網速度に急激な変化のある場合，例えばナンゼンの閉鎖ネットによる区分採集の場合等には内容物の溢出の危険がある。かえし網を網口にとりつけるのは之を防止する上には効果があるであろうけれども，流入水量を定める際には新たな障害となると考えられる。

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サメ肉腐敗の微生物化学的研究

第2報　尿素分解細菌の分離及び其のUrease Activityについて

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Studies in the Bacteriological Chemistry of Shark Muscle Spoilage

II. On the isolation of urea splitting bacteria and their urease activity

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Abstract

In the present work, the author has isolated urea splitting bacteria from spoiling shark muscle, and observed their urease activity and other characters.

The results can be summarized as follows:

1) Twenty three strains (K1～K23) were isolated by enrichment technique with media as shown in Table 1.

2) Five strains (K6, 8, 9, 10, 13) had stronger urease activities than the other strains.

3) Among these 5 strains, only one (K8) was able to grow on medium using urea only as nitrogen source.

4) In 3 strains (K6, 8, 10) among those 5 strains, the strength of urease activity was not influenced by existence of urea in medium, on the other hand, in the 2 strains (K9, 13), the strength of the urease activity increased.

前報[1]に於て著者等はサメ肉の腐敗に於ける細菌群の消長及びサメ肉抽出液のurease活性の変化を観察して，サメ肉の腐敗に於ける尿素分解の大部分が細菌の酵素によるものであり，又細菌組成の変化とurease活性との間には密接な関係があるだろうと推論した。サメ肉の腐敗に於ける尿素分解の大部分が尿素分解細菌によるものであろうと云う事はすでに清水[2]，高橋[3]，木俣[4]等によつても報告されているところであり，一応妥当であると考えられる。然しながらサメ肉に於てどの様な種類の細菌によりどの様な条件の時に最も活潑に尿素の分解が行われるか，又腐敗生産物，防腐剤は勿論，此等細菌の生活環境の物理的，化学的条件の変化がurease活性又はurease形成能力にどの様な影響を及ぼすか等の点に就ては殆んど明らかでない。著者は以上の点を究明する事を終極の目的として，先ず本報に於ては腐敗過程に於けるサメ肉より後に述べる様な方法で，比較的尿素分解に関係の深いと思われる細菌20余株を分離し，各菌のurease活性を測定比較し，又二三の性質を観察して若干の結果が得られたので報告する。尚細菌の urease 活性に関する研究は古くMusaclusが尿中の尿素分解作用が *Micrococcus ureae* による事を明らかにしてから多くの研究が報告されており，最近に於てもStuart等[5]及びFerguson等[6]による *Bacillus proteus* のurease活性，Evelyn等[7]による *Brucella* の urease 活性に関する研究等が報告されている。然し之等の研究の多くは bacteria の urease により一定の細菌を他から区別する目的　即ち分類学上の目的で行われたものが多い様に思われる。

I　供試菌の分離及び分離菌の二三の性質

実　験　方　法

（i）分離方法：前報の研究の実験IIに用いた試料について同様の方法，即ち，鮮度の良好なホシザメ（*Mustelus manazo* BLEEKER）を可及的に室中細菌の汚染を防いで調理肉挽して，10 g ずつ殺菌綿栓フラ

スコに分け，15～20°C に貯蔵した試料を一定日数毎に無菌 homogenizer にて乳状となし，常法に従い殺菌生理的食塩水で適当に稀釈し，次に述べる様な Enrichment technique[8] により細菌を分離した。即ち Table 1 に示した3種の液体培地に上記試料乳液一定量を接種し 30°C で培養を続けると，通常24～48時間にて混濁が認められるので，その一白金耳を同一組成の培地に継代培養する。2代目以後は菌の増殖が速かである故10数時間毎に2回継代を繰返した後，同一組成の固形培地を用いて常法通り平板分離を行つた。尚此の様な方法によれば殆んど大部分は同一若しくは2種程度のコロニーとなる。又Table 1に示す3種の培地を用いた理由は先ず medium I及びIIに発育する細菌は一般に尿素細菌と云われているものであり，又 medium III に発育する細菌は一般に non exacting bacteria と云われ，N源として栄養的に厳しくない菌で，いずれも比較的尿素分解に関係が深いと思われる事によるものである。

Table 1.　Composition of media

Medium I		Medium II		Medium III	
Urea	30g	Urea	20g	NH_4Cl	6g
K_2HPO_4	0.5g	$CaCl_2$	0.1g	$MgSO_4$	0.2g
$C_6H_5O_7Ca_3$	10g	Beef ext.	5g	KH_2PO_4	3g
(Agar	20g)	NaCl	0.1g	Na_2HPO_4	6g
Water	1000ml	K_2HPO_4	1g	Glucose	4g
pH	7	$FeCl_2$	0.01g	(Agar	20g)
		$MgSO_4$	0.3g	Water	1000ml
		(Agar	20g)	pH	7
		Water	1000ml		
		pH	7		

ii) 分離菌の上その性質としては先ず各菌の形態を常法により観察し，又各菌の上記3培地及び普通寒天培地に対する発育を斜面培養法により観察した。

実　験　結　果

以上の様な方法により分離した細菌は Table 2 に示す如く Bacilli 12株，Cocci 11株の計23株で，此の中 medium I により分離したものがK1～K3の3株，medium II により分離したものがK4～K16の13株，medium III により分離したものがK17～K23までの7株である。以上23株の細菌は Table 2 に示した様にいずれも普通寒天培地に良く発育し，前記3培地に対する発育を観察した結果を同じく Table 2 に示した。即ちN源として尿素のみ含有する medium I にはK1，2，3，5，8，12及びK22の7株より発育し得なかつたが，N源として尿素の外に Beef extract をも含む medium II には若干の例外を除いて大部分が発育し得る，又N源として NH_4Cl のみを含む medium III には約半数の細菌が発育した。

II　分離細菌の urease 活性

実　験　方　法

i) 特殊培地による定性的測定：

実験1に於て分離した細菌K1～K23の23株をScheider[9]の方法に従い，指示薬として，metacresol sulfonphthalein を含む半固体の尿素含有特殊培養基に接種し，30°C にて24時間及び48時間培養し，尿素の分解による指示薬の変化から urease 活性を観察した。即ち，指示薬の変色が表面から培地の半分目までを越えるものを(++)，変色が半分目まで及ばぬものを(+)，表面だけのものを(±)，変化のないものを(−)とする。尚尿素のみを除外した同一培地を用いて培養せるものを対照とした。

ii) Warburg 検圧計による洗滌菌体浮游液 urease 活性の定量的測定：

各分離細菌を bouillon-agar 及び2%尿素添加 bouillon-agar に接種し，30°Cで22～24時間培養を行い常法に従い集菌し冷水にて3回洗滌後光電比色計により日立(C)フィルターを用いて水を blank として透過率が30%となる様冷水に懸濁せしめ，これを酵素液として下記の如き条件で尿素の分解により生ずる CO_2 の量を Warburg 検圧計により一定時間毎に測定し，此の量を urease 活性とした。測定条件は，温度30°Cで

主 室　洗滌菌体浮游液 0.5ml，終末濃度 0.067M, phosphate buffer pH 6.9，1.1ml
側 室　2M 尿素溶液（終末濃度 0.4M，約2%）0.4ml
副 室　20%KOH，0.4ml（O_2測定用）

であり，すべての測定は自家呼吸によるO_2の消費及びCO_2の増加を補正した。尙個々の細菌 urease の最適反応条件が同一であると考えられず，現に内野等[10]の報告によれば数種の細菌 urease の最適反応 pH を測定し，少しずつのずれが認められたと述べているが，分離細菌23株の個々の最適反応条件をあらかじめ測定する事は技術上困難であり，又本研究の現段階に於てはそれまで厳密な測定を必要としないと思われたので，本実験に於ては上記の如く Sumner 等[11]が得た刀豆結晶 urease の最適条件である終末尿素濃度2.5%，phosphate buffer pH 6.9 をすべての菌株に適用した。又予備実験によれば各菌株により多少の相違があつたが，450mμフィルター，10mmキユーベツトで，透過率30%の浮遊液は1 ml 中に dry cell 1.8mg を含み，此の濃度の前後に於て浮游液中の dry cell 重量即ち濁度と吸光度とは直線的関係にあり Beer の法則が成立した。

Table 2. General characters of the isolated bacteria

Strain No.	(A)	(B)	(C)	Growth character							
				Medium (I)		Medium (II)		Medium (III)		Bouillon agar	
				24hr.	48hr.	24hr.	48hr.	24hr.	48hr.	24hr.	48hr.
K 1	C	I	3	+	+	±	±	−	±	++	++
2	C	I	3	±	+	±	±	−	−	+	+
3	C	I	3	+	+	±	±	±	±	++	++
4	B	II	1	−	−	+	+	+	++	++	++
5	C	II	5	+	+	+	+	+	+	++	++
6	C	II	5	±	±	+	+	±	±	+	++
7	C	II	5	±	±	+	+	+	+	++	++
8	B	II	15	−	+	±	+	−	−	+	+
9	C	II	11	−	±	+	+	±	+	++	++
10	B	II	11	−	±	±	+	−	−	±	+
11	C	II	21	−	±	+	++	+	+	++	++
12	C	II	24	±	+	+	+	+	+	++	++
13	B	II	24	−	−	±	+	−	−	+	+
14	B	II	24	−	−	+	++	+	+	++	++
15	B	II	21	±	±	+	+	+	+	++	++
16	B	II	5	−	−	±	+	−	−	±	+
17	B	III	1	−	−	+	+	++	++	++	++
18	B	III	17	−	−	±	±	+	+	+	+
19	B	III	17	−	−	±	±	+	+	+	+
20	B	III	28	−	−	±	+	±	+	+	+
21	C	III	28	±	±	+	+	+	+	++	++
22	C	III	1	±	+	+	+	+	+	++	++
23	B	III	2	−	−	±	+	+	+	+	+

(A) Form, B—Bacilli C—Cocci　(C) Days of isolation
(B) Used medium for the isolation　++ abundant, + moderate, ± slight, − negative

Table 3. Scheider test of the isolated bacterial urease

Strain No.	Urea cont.	Urea free
K 1	−	−
2	−	−
3	−	−
4	+	±
5	±	−
6	+	−
7	±	−
8	+	−
9	++	−
10	±	−
11	±	−
12	−	−
13	+	−
14	±	−
15	−	−
16	−	−
17	++	+
18	+	+
19	+−	++
20	−	−
21	±	−
22	±	−
23	±	−

++ colorimetric reaction (yellow to purple) diffusing from the surface and beyond half the length of the medium
+ diffusion from surface and not beyond half the length
± colorimetric change at surface
− no change

実験結果

以上の方法により各分離菌のurease活性を定性的に観察した結果は Table 3 に示した様に，urease活性が(++)と判定されるものはK 9 の1株のみで，(+)と判定されるものは3株，(±)と判定されるものが若干認められた。然し此の結果のみでは確実な判定が困難の如く思われたので，前述の方法により各菌の bouillon-agar 及び2%尿素添加 bouillon-agar 上に発育せる菌体の urease 活性を定量的に測定した結果は Fig. 1に示す如くである。 Enrichment medium として medium II を用いて分離したK6，8，9，10，13の5株は特異的に活性が強く，他の菌株に於ては特に注目すべき活性が認められなかつた。又この結果から見て明らかな如く二三の例外を除き一般に尿素添加培地に発育した菌体は普通培地に発育したものに比し若干活性度が増大しており，特にK 9及び13の2菌株に於ては顕著である。以上の事実は各菌の Q_{CO_2} (dry cell 1 mg が1時間反応して生ずる CO_2 の量，本実験に於ては最初の10分間の反応により生じた CO_2 の量から計算により求めた）を求めてみれば更に明らかに観察される（Fig. 2）次に対照として当教室保存菌種の中一般に腐敗細菌と呼ばれている *Bac. mesentericus ruber* 及び *Pseudomonas fluoresens* MIGULA 又古くから尿素細菌の代表的菌株と云われている *Bac. pasteurii* (MIQUEL) 及び Gale[12] が細菌 urease の研究に用いた *Micrococcus lysodeikticus* の尿素添加培地に発育した菌体のurease活性を前同様の方法により測定した結果は Fig. 3 に示す如くである。即ち *Micrococcus lysodeikticus* のみは中程度の活性を示したが，他の3菌は殆んど注目さるべき活性を示さなかつた。然し此の活性度も前述の5菌株の中比較的活性の低かつたK 9 株に相当する程度であつた。尚 *Bac. pasteurii* の活性が弱いと云う事は意外な事実であるが本菌は東大応用微生物研究所より分譲されたもので分類学上正しい菌株であるにもかかわらず尿素添加培地に数度前培養を行つても活性の増大が認められず，分譲を受けた以前に既に酵素活性が変異したものではないかと考えられる。

考　　察

以上の実験結果から明らかな如く比較的尿素分解に関係が深いのではないかと云う予想のもとに分離した細菌23株の中特にurease活性の強かつたものは5株のみで他は殆んど注目すべき活性が認められず，此等5株はすべて Enrichment medium として medium II により分離されたものでK 8株を除く他の4株はN源として尿素のみの medium I には殆んど発育を示さなかつた事と，又 Enrichment medium として medium I により分離された3株及び他の medium により分離されたものの中 medium I に発育可能だつた4株の計7株

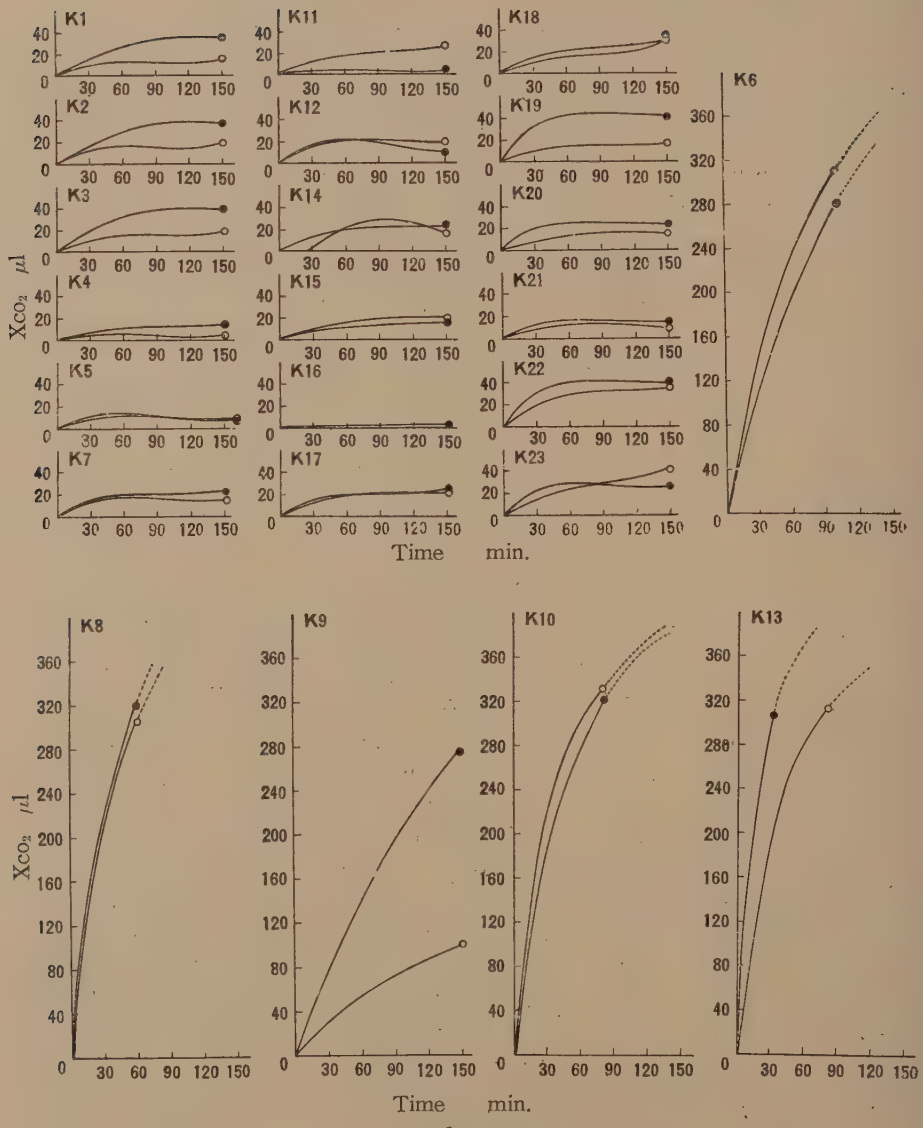

Fig. 1. The urease activity of cell suspention of the isolated bacteria that was estimated at 10 minuts intervals in reaction by Warburg's apparatus at pH 7.1 and 30°C.

● the cell grew on 2% urea containing bouillon agar
○ the cell grew on urea-free bouillon agar

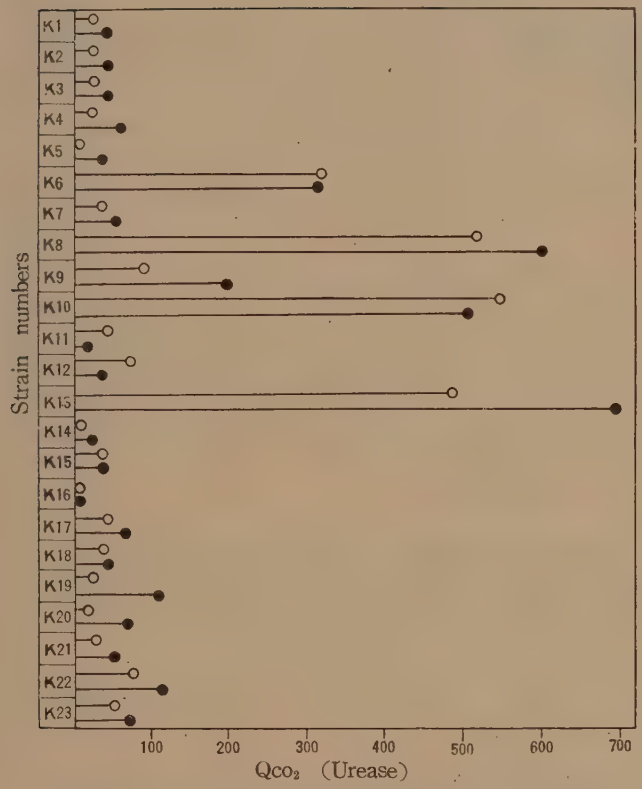

Fig. 2. The QCO_2 (urease) of the isolated bacteria

These were calculated from the initial 10 minutes reaction.

● the cell grew on 2% urea containing bouillon agar
○ the cell grew on urea-free bouillon agar

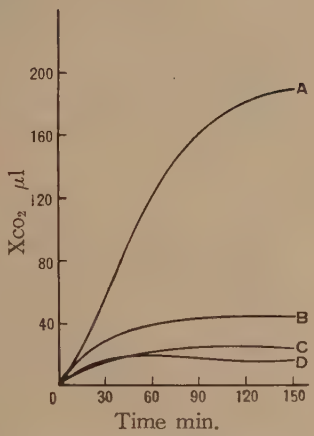

Fig. 3. The urease activity of cell of 4 species of preserved cultures which grew on 2% urea containing bouillon agar

These results were estimated in Fig. 1.

(A) *Micrococcus lysodeikticus*
(B) *Bac. mesentericus ruber*
(C) *Bac. pasteurii* (*Miquel*)
(D) *Pseudomonas fluorescens Migula*

の中K 8 株を除く他の菌株には殆んど活性が認められなかつた事からN源として尿素のみを含む培地に発育し得る細菌と云えども必ずしもurease活性が強いとは限らず大多数は尿素を増殖に利用する際分解と云う過程を取らず他の方法により直接利用するものではないかと考えられる。木俣等[13]及び Zobell等[14]は海洋に於ける尿素分解細菌に関する研究を行い尿素分解細菌は次の3型に分類されると指摘している。即ち

a) N源として尿素のみでも充分発育を遂げるが強力なる尿素分解作用を営まぬもの

b) N源として尿素のみでも充分発育し且つ旺盛な尿素分解を行うもの

c) N源として尿素のみが存在する場合には全く又は殆んど発育しないが他の有機分解物が共存すれば充分発育し且つ旺盛な尿素分解を行うもの，等である。

併し著者等の分離した前述の5株の中K 8 株はb)に属するものと思われ又K6，9，10，13の4株はc)に又 K1，2，3，5，14，22はa)に属するものではないかと考えられる。然し前記5株はいずれも全然尿素を含まぬ培地に発育した菌体でも相当のurease活性が認められ，特にK6，8，10の3株は尿素を含む培地に発育した菌体も，含まぬ培地に発育した菌体も殆んど同程度の活性を示し発育の際の存在には殆んど無関係の

如くであり，此等の菌株に於てはureaseは構成酵素的に生産されるものではないかと考えられる。一方K9，13の2株に於ては尿素を含む培地に発育した菌体は明らかに活性が増大を示しており特にK 9株に於ては著しく，此等2菌株に於てureaseが適応的に増大されたものであろうと考えられる。いずれにしろ腐敗過程に於けるサメ肉から特異的にurease活性の強い細菌5株を分離する事が出来，此等の活性はFig. 3に示す様な他の一般腐敗細菌のそれに比しはるかに強力であると云う事実から考えて此等の細菌がサメ肉の腐敗に於ける尿素分解に主要な役割をなしているだらうと云う事は当然考えられる事で，今後此等の細菌のureaseの特異性並びに生活環境の物理化学的条件かurease生産にどの様な影響を及ぼすかを究明する事により板鰓類魚肉のammonia発生機構解明の一助となり得ると考えられる。

要　　約

前報に引続き腐敗進行過程に於けるサメ肉よりTable 1に示す3種の培地を用い，Enrichment techniqueにより比較的尿素分解に関係の深いと思われる細菌23株を分離し，そのurease活性を観察せるに23株の細菌の中K6，8，9，10，13の計5株が特異的に活性が強く，此の5種の中N源として尿素のみの培地に発育し得たものはK 8の1株のみであつた。又K6，8，10の3株に於ては培地中の尿素の存在にその活性度は殆んど影響されず此の3株に於てはureaseは構成酵素的に形成され，又K9，13の2株に於ては培地に尿素を添加する事により活性度が増大し，此等に於ては適応的に形成するものと考えられる。いずれにしろ此の様な活性度の高い菌種はサメ肉腐敗に於ける尿素分解の主要な役割をなすであらうと推察した。

終りに臨み，本報告の御校閲を賜つた本学谷川教授，直接実験の御指導を賜つた本学故長尾助教授，菌株（*Bac. pasteurii MIQUEL*）の分譲を賜つた東京大学応用微生物研究所飯塚助教授並びに実験の一部を担当された本学学生川村善造の諸氏に深甚の謝意を表する次第である。

尚本研究費の一部は文部省科学研究助成金に依るものであり，茲に感謝の意を表する。

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サケ罐詰の製造に関する研究

第1報　冷凍魚を原料としたサケ水煮罐詰の冷凍臭について

（1）　冷凍魚を原料とした罐詰の異臭成分について

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Studies on the Manufacture of Canned Salmon

I. The odor in canned salmon manufactured from frozen fish as the raw material

(1) Chemical components of the odor of canned salmon made from frozen fish

Eiichi TANIKAWA, Terushige MOTOHIRO and Shigeo SHOJI

Abstract

With the use of frozen fish as a raw material for canned salmon, there is often formed a particular detestable odor or flavor in the can. The chemical components of the odor which could be separated by steam distillation from canned salmon, were detected by paper partition chromatography and a detector tube.

The substances thus detected as the components of the odor formed in the canned salmon, were piperidine, formic acid, formaldehyde, and δ-aminovaleraldehyde. On the other hand, in canned salmon which was made from fresh salmon used as control, those components were not detected. In the succeeding papers information will be given on the source of the odor.

北洋鮭鱒漁業においても原料の一部は冷凍品として内地の陸上罐詰工場に移送され，そこで罐詰に製造されている。この冷凍魚を罐詰とした製品は生鮮魚を用いた製品に比し，所謂冷凍臭を有し罐詰検査に際し，品質が劣ると云われる。

本研究はサケ罐詰の冷凍臭の生成原因を究明し，更にその防止対策を講ずる目的を以て行つたものである。即ち，先ず所謂冷凍臭を有する罐詰の臭気成分を知るために実験を行つた。

実験方法

先ず罐詰の開罐後罐内容物を固形分と液分とに分け，固形分を常法に従つて水蒸気蒸溜した。此の場合，約40分間水蒸気蒸溜を継続すれば試料とした固形分には臭気が感ぜられなくなつた。尚此の程度の時間，水蒸気蒸溜すれば溜液は約200ccとなり，且つ溜液には開罐時の内容物と同様な臭気が感ぜられる故，呈臭成分は総て溜液中に移行したものと考えられる。

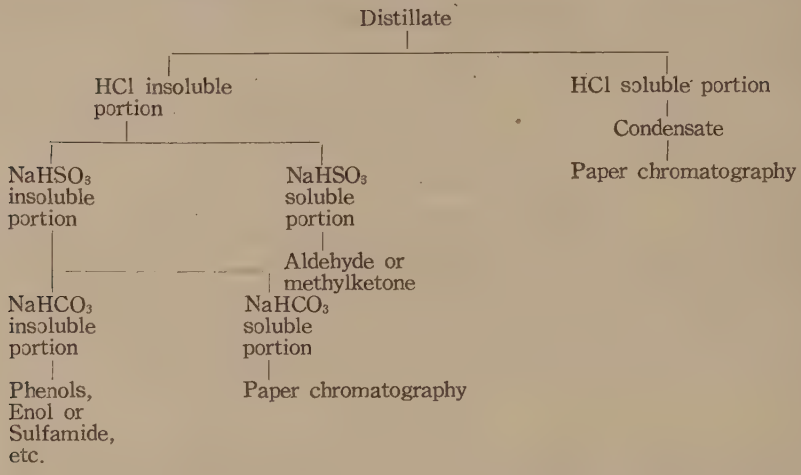
上記の如くして得られた溜液は，次の Scheme 1 の如き操作により各区分に分けた。

各区分における化合物の検出には，塩基及び酸ではペーパークロマトグラフ法，アルデヒド及びメチルケトンには還元性，若くはヨードフォルム反応，ジアゾ反応，フクシン亜硫酸と稀硫酸による呈色反応を組合せて検出した。

又，罐詰肉には硫化水素臭が強く感ぜられる故，シリカゲルを担体とし，醋酸鉛を検知剤とした検知管に

より硫化水素を定性的に検出した。

Scheme 1. Fractionation of the distillate obtained by steam distillation with canned salmon meat



結果及び考察

冷凍臭を有する罐詰の揮臭化合物を検索した結果は第1表の如くである。

第1表によれば対照とした罐詰即ち生鮮サケを直ちに罐詰とした製品（罐詰検査合格の良好罐）では揮臭成分として硫化水素，カダベリン，蟻酸が検出されたのに対し，冷凍臭を有する罐詰には硫化水素，カダベリン，蟻酸の外にピペリジン，醋酸，フォルムアルデヒド，δ-アミノバレルアルデヒドが検出された。

此の結果より，冷凍臭を有する罐詰は明らかに正常罐より多種類の揮臭成分を含有していることがわかつた。即ち冷凍臭を有する罐詰肉にはピペリジン，醋酸，フオルムアルデヒド，δ-アミノバレルアルデヒドが異臭成分として存在するものと思われる。之等の異臭成分が如何なる理由により発生したかは不明であるが，ピペリジン，フォルムアルデヒド，δ-アミノバレルアルデヒド等は何れも魚肉の鮮度が低下する際，遊離アミノ酸が分解して生ずるものであるから，サケを冷凍貯蔵中その成分が化学的変化をする場合を考慮されなければならない。

要　　約

冷凍サケを原料としたサケ罐詰において所謂冷凍臭を呈する物質は，その罐詰肉を水蒸気蒸溜し，その溜出物につきペーパークロマトグラフ法，其の他の方法で検索したところ，ピペリジン，醋酸，フォルムアルデヒド，δ-アミノバレルアルデヒド等であることが判つた。尚生鮮サケを罐詰とした肉について，同様な方法で検索したところ，前記の化合物は見出されなかつた。之等冷凍臭成分が何処から来るかについては後報において述べる。

Table 1. Components of the odor and chemical composition of canned salmon

Sample can	Volatile basic nitrogen (mg%)	Volatile acid (mg%)	Total nitrogen (%)	0.2% NaOH soluble nitrogen (%)	Ether extract (%)	Acid value	Saponification value	Iodine value	Peroxide-O_2 (%)	Components of the odor
Canned salmon, by fresh material	29.6	1.2	3.46	0.43	7.8	3.5	186.6	147.7	0.40	Hydrogen sulfide, Cadaverine, Formic acid.
Canned salmon, by frozen fish (With a particular odor)	31.3	1.7	3.20	0.89	6.3	5.5	180.7	151.5	0.67	Hydrogen sulfide, Cadaverine, piperidine, Formic acid, Acetic acid, Formaldehyde, δ-aminovaleraldehyde

サケ罐詰の製造に関する研究

第2報　冷凍魚を原料としたサケ水煮罐詰の冷凍臭について

（2）冷蔵室内の臭気について

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Studies on the Manufacture of Canned Salmon

Ⅱ. The odor in canned salmon manufactured from frozen fish as the raw material

(2) On the particular odor in the refrigerated warehouse

Eiichi TANIKAWA, Terushige MOTOHIRO and Shigeo SHOJI

Abstract

On the formation of the odor in the canned salmon which was made from frozen fish, two causes are considered. One of them is that the oxidative decomposition of salmon fats during refrigeration at freezing temperature, resulted in the formation of a great variety of decomposition products such as aldehydes or volatile acids.

In fact, when salmon was even freshly frozen at −15°C, and after 50 days' storage at the same temperature, it formed a sufficiency of decomposition products to be able of evaluation organoleptically. A second cause is that the odor of the refrigerated warehouse had penetrated into meat tissue of salmon which was stored in that room.

By careful study of the odor of the refrigerated warehouse for fish, it was clarified that the odor consists of ammonia, ethylene, formaldehyde, and acetaldehyde.

前報[1]では冷凍臭を有する罐詰肉の臭気成分を検索し，正常罐の臭気成分と比較してピペリジン，フォルムアルデヒド，δ-アミノバレルアルデヒド，醋酸が冷凍臭の原因となることを認めた。之等の冷凍臭の発生原因には，次の如き二様の場合が考えられる。即ちその一つは冷蔵庫固有の臭気が冷凍魚に移り，之が罐詰内に移入される場合，又他の一つはサケを冷凍貯蔵している間にサケの化学的成分が変化して生じた場合である。

本報では，斯様な点を明らかにするため冷凍室内の臭気成分の検索を行ったのでその結果を述べる。

実験方法

従来，冷蔵庫内の臭気について行われた研究結果は多く見受けられるが，之等は何れも冷蔵庫内の換気法について考究されたものであり，しかもその大多数は果実を貯蔵した場合であって，魚類を対象とした場合は殆んど行われていない。

之等の果実冷蔵庫の臭気の研究においては，果実類を冷蔵中その発散する臭気を除去するため，椰子殻活性炭を果実の近辺に置き吸着させる方法が考案されている[2]ので，著者等も冷蔵庫内の臭気を検索する際臭気成分を種々の吸着剤に吸着させるために脱脂綿，活性アルミナ，酸性白土，活性炭等を用いた。即ちこれ等吸着剤をサケの収容されている冷蔵室及び空冷蔵室内に3ヶ月間放置して臭気を吸収せしめた。

上記の吸着剤は何れも臭気を吸収するが就中，活性炭は最も良く吸着性を有するもの丶如くである。尚吸着剤に吸着された臭臭物質は実験室内で24時間以上放置すれば揮散してしまうので，実験室に持ち帰り次第直ちに分析に供した。

吸着剤の処理操作は次に示した。

Scheme 1. Treating procedure for an absorbent which adsorbed the odor in refrigerated warehouse

Add petroleum ether to the absorbent, and shaking. Repeat the treatment

Petroleum ether soluble fraction	Petroleum ether insoluble fraction
	Wash the absorbent two times with petroleum ether, then add water

上記の如く大別した石油エーテル可溶区の物質は，一部を採取して，窒素の定性試験を行つたところ陽性であつた。それ故，稀塩酸の少量と数回振盪し，此の溶液を合し次の如く処理した。

Scheme 2. Hydrochloric acid procedure for treating petroleum ether soluble fraction

Dil. HCl soln. of petroleum ether soluble fraction

↓ Add NaOH soln.

↓ Distillation

Base fraction	Distillate
	↓ Add NH_4Cl soln.
	↓ Add acetic acid
	↓ Neutralize

又，石油エーテル可溶区の一部を採取し，その還元性を検したところ陽性であつたので，残部に稀薄な重亜硫酸ソーダ水溶液を加え振盪し次の如く処理した。

Scheme 3. Sodium bisulfite solution procedure for treating petroleum ether soluble fraction

Petroleum ether soluble fraction + $NaHSO_4$ soln.

↓

Distillate with dil. H_2SO_4

↓

Distillate	Residue

次ぃ，石油エーテル可溶区に重炭酸ソーダ水溶液を加えて振盪し，之に稀塩酸を加えて蒸溜し，溜出液を得た。又，石油エーテル可溶区を稀苛性ソーダ溶液と振盪し，之に稀塩酸を加えた処，析出物はなく悪臭を感じた。

尚 Scheme 3 の操作において石油エーテル不溶区即ち石油エーテルを加えて振盪した後の吸着剤には臭気がなかつたので，此の区分の操作は省略した。

上記の如き操作により，塩基，アルデヒド，酸若くは強酸性物，及びフェノール若くは弱酸性物を分離し，之等の成分をペーパー・クロマトグラフ法により検索した。而して石油エーテルを稀苛性ソーダ溶液と振盪し，稀塩酸を加えた区分では析出物が得られなかつたので，此の区分の検索は行わなかつた。

Scheme 2に示した操作により得られた塩基は再び之を塩酸塩となし一次元上昇法により展開した。溶媒としては *n*-ブタノール・醋酸・水（3:1:2）を用い，顕色にはニンヒドリンを噴霧した[3]。酸性及び強酸性物の中，悪臭成分は低級脂肪酸の如き低分子の物質に限定される故，揮発酸のヒドロキサム酸を合成し，水飽和 *n*-ブタノールで展開し，飽和塩化第二鉄水溶液飽和 *n*-ブタノールで顕色した[4]。

冷蔵庫臭には上記の有機性悪臭成分の外，所謂工業ガス成分として存在する物質もあると考えられ，之を検索するため，検知管（内径4 mm，全長15cmのガラス管）を組合せ，ガス分析を試みた。此のガス分析は定性的に行い，定量的な操作は行わなかつた。

燐化水素と硫化水素を検出する際，燐化水素の検知管内の硫酸銅及び塩化第二水銀は硫化水素により黒く着色するので，最初の検知管で硫化水素を吸着させ，次の検知管で燐化水素を検出する必要があつた。其の他の共存ガスの影響は受けない[5]ので，各種検知管の連結順序は不同とした。尚，検知剤の担体としては，シリカゲル粒を用い，検知剤には重硫酸ガスに対しては重クロム酸カリ，アンモニアに対しては含水第一塩化コバルト，エチレンに対しては硫酸パラジウム，フォルムアルデヒドに対しては硫酸銅及び塩化第二水銀の混合物を用いた。

結果及び考察

Scheme 2 において得られた塩基性物質は之をピクリン酸塩の結晶とした。その顕微鏡写真は第1図に示したが，此の組成分は3種類あるのではないかと考えられた。又，ペーパー・クロマトグラフの結果は原点附近よりカダベリンの位置に相当する近辺まで発色帯が認められ，組成分の分離は困難であつたが，恐らく2～3種の成分よりなるものと思われた。p-キノンとの呈色反応は陽性であつたことから，此の組成分中にはピペリジン系統の化合物があるものと推定される。結晶形からみればピペリジン，δ-アミノバレリアン酸，ピペリジン—アセトアルデヒド反応生成物の存在が想定されるが，稀塩酸に溶解し而かも苛性ソーダに溶解する物質は検出されなかつた故，δ-アミノバレリアン酸の存在は不確実となる。従つて，クロマトグラフにより検出されたカダベリンを冷蔵庫臭の一成分と考えることが妥当であらう。対照とした空冷蔵室中には之等の塩基は全く検出されなかつたので，上記の如き塩基性物質は冷凍サケが収容されていたことによつて生成したものと思われる。即ち小幡等[3]はサケ粘液成分としてピペリジン系化合物を分離し，魚臭成分となり得ることを報告している。著者等も本実験中サケを冷凍中，その冷凍室内の臭気に此の系統の化合物の存在することを認めたが，小幡等が述べた如く若しピペリジンの前駆物質がリジンであるならば次に示されるように，その分解過程の中間体としてカダベリンが存在してもよいと考えられる。

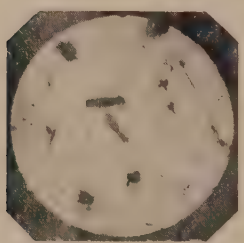
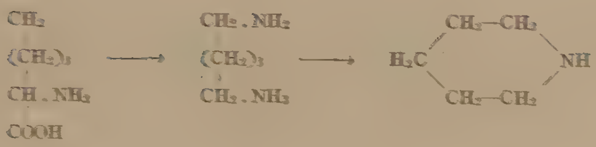


Fig. 1. Microphotograph of picrates of basic fraction（×320）



lysine　　　cadaverine　　　piperidine

尚，クロマトグラフにおけるドラーゲンドルフ反応は擬陽性であつたが，之は恐らくトリメチルアミンに[illegible]

[illegible]

ジアゾ反応及びレゾルシン反応が夫々陽性若くは擬陽性であつたことは，フォルムアルデヒド，アセトア[illegible]

[illegible]アミノバレルアルデヒド及びピペリジン・アセトアルデヒド反応生成物（1.1-[illegible]）[illegible]
アミノバレルアルデヒドの如き呈臭物質によるものと考えられる。又，アセトアルデヒドもピペリジンとの[illegible]

[illegible]

[illegible]

[illegible]燐化水素，フォルムアルデヒド，アセトアルデヒドが検出されたのに対し，空冷蔵室内にはアンモニア，エチレン，フォルムアルデヒド，アセトアルデヒドが認められたに過ぎなかつた。前述の如くアルデヒド類は[illegible]したものと考えられる。

[illegible]

從つて前報の冷凍魚を原料とし，異臭のある罐詰について得られた結果と本実験の結果とを比較して考察すれば，サケを収容した冷蔵室の臭気成分の組成も，異臭のある罐詰の臭気成分の組成も略々一致していることがわかつた。即ちサケを収容した冷蔵室の臭気成分であるカダベリン，ピペリジン，δ-アミノバレルアルデヒド，フォルムアルデヒド，蟻酸等は恐らくサケの冷凍貯蔵中に発生し，そのサケが罐詰として製造される際も臭気成分か或る程度残存して，これが罐詰内に移入されたと考えられる。

要　　約

冷凍サケを原料としたサケ罐詰の異臭物の生成には二通りの原因が考えられる。その一つは，サケを冷凍している時に，その体脂肪か冷蔵庫内で酸化し，低級な分解生産物を生じ，アルデヒド類，揮発酸を生成することで，事実サケを直ちに冷凍（−15°C）貯蔵中（50日間位）既に官能的に判る程度の分解物を生成している。他の一つは，冷蔵庫内の特臭であつて，これが魚体に移るためと思われる。冷蔵庫内の特臭を検出したところ，アンモニア，エチレン，フォルムアルデヒド，アセトアルデヒド等が見出されている。

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サケ罐詰の製造に関する研究

第3報　冷凍魚を原料としたサケ水煮罐詰の冷凍臭について

（3）　サケ冷凍貯蔵中の油脂の変化

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Studies on the Manufacture of Canned Salmon

III. The odor in canned salmon manufactured from frozen fish as the raw material

(3) On the oxidative rancidity of salmon fats during cold storage

Eiichi TANIKAWA, Terushige MOTOHIRO and Shigeo SHOJI

Abstract

Fish which were fresh or unfresh in initial quality, and fish to which was added "Sustane 1-F" (B. H. A.; Butylated hydroxyanisole) were stored in a refrigerated room at −15°C, and oxidative changes in these three sorts of material were observed.

The results obtained are summarized as followed:

(1) From variations in values of acid, saponification, iodine, ether extracts and peroxide-oxygen respectively, it seems clear that the oxidation process occurred in comparatively early period of the storage, and that the process was inactive in the later period in each kind of sample.

(2) Oxides and peroxides has tended to increase throughout the storage period. In later part of that time, however, the oxides and peroxides once formed have decreased, due to the occurrence of the chemical reaction of decomposition or polymerization.

(3) It was observed that fish added "Sustane 1-F" had inhibited the oxidation as compared with non treated material. This is considered to be due to the fact that the unsaturated fatty acids in salmon fats were made non-subject to oxidation by the addition of the "Sustane 1-F".

(4) Sample which was unfresh in initial quality, was oxidized more easily throughout the storing period than that which was fresh. This is considered to be caused by the increase of the amount of free fatty acids in salmon fats owing to decrease in the freshness of salmon.

(5) Through the periods of the freezing storage, salmon fats have suffered hydrolysis, and higher fatty acids formed have further decomposed to lower fatty acids or aldehydes which became the constituents of the odor of the refrigerated warehouse.

著者等は前報においてサケを収容した冷蔵室中には所謂冷蔵庫臭以外の臭気成分の存在することを認めた。而してその臭気成分は恐らくサケ肉より生成されたものと考えたが，その生成機構を解明するに至らなかつた。そこで，斯の点を明らかにするため，サケを冷凍貯蔵した際の成分の変化をみた。

本報ではその中，魚体脂肪の冷凍貯蔵中の変化について述べる。

実　　験

試　料：

供試サケは北海道で漁獲された鮮度の良好なものを市場より購入し，内臓を除去した後−15°C の冷蔵庫内に放置し，実験の都度，魚体の一部を截切して材料に供した。又別の個体を実験室内に一夜放置して鮮度を人工的に低下させ，その肉中の揮発性塩基窒素量が 15mg% 程度となつた後，内臓を除去し，−15°C の冷蔵庫内に貯蔵した。此の外，冷凍貯蔵中にサケ体油の酸敗を防止するため butylated hydroxyanisole (3-tert-butyl-4-hydroxyanisole 及び 2-tert-butyl-4-hydroxyanisole の混合物，商品名 "sustane 1-F") 0.008g を 80cc のエタノールに溶解し，之を更に 8,000cc の水溶液としたもの，即ち 1/1000 の濃度の水溶液を調製し，鮮度良好なサケを上記の如く内臓を除去した後，此の溶液中に 1 時間浸漬した。浸漬後のサケは −15°C の冷蔵庫内に貯蔵し，前記 2 試料と同じく脂肪の変化をみた。

試料調製法：

冷蔵庫内に貯蔵したサケは実験の都度，その一部を截切し実験室に持ち帰り，冷水中で解凍し，表皮を除去し，乳鉢で磨細した。肉組成から体油を抽出する際，一般には乾燥させた肉に溶媒を用い，即ち連続抽出装置によつて抽出操作を行つているが，然し此の操作の欠点は多くの研究者により既に指摘されている如く，乾燥中及び長時間に亘る熱抽出操作中に油脂の酸化が進行し，生成過酸化物が熱溶媒中で分解されるが，それ故，著者等は Rockwood[2], Watts & Peng[3] 等の方法に従い脱水芒硝並びにエーテルをサケの肉組成に加え waring blendor に移し，周囲を氷で冷却し乍ら 10分間攪拌抽出した。然し此の方法によれば，サケ肉組成中の油脂抽出率は熱抽出法に比し幾分劣つていて操作終了後も猶，肉組成中に脂肪分が残留するので，エーテル抽出物量を求める場合はソックスレー脂肪浸出器により熱抽出を行つた。

実験方法：

酸価及び鹸化価の測定： 抽出油脂 2g をフラスコ中に秤量し，予め中和したアルコール 25cc を加えて温めフエノールフタレンを指示薬として N/2 アルコール性カリ液で滴定して酸価を測定し，次にアルコール性カリを注加して 50cc となし，湯浴上で 1 時間鹸化し，N/2 塩酸で滴定した。

沃素価： Wijs 法により測定した。

過酸化物酸素量： 抽出油脂を氷醋酸 6，四塩化炭素 4 の割合で混合した液 50cc に溶解し，次に飽和沃度カリ 1cc を加え，1 時間冷暗所に放置した後 N/100 チオ硫酸ソーダで滴定した。N/100 チオ硫酸ソーダ 1 cc は 0.00008g の活性酸素に相当する。

結果並に考察

サケ冷凍貯蔵中の成分油脂特数の変化は第 1 表に総括した。又第 1 図から第 3 図までは夫々，酸価，鹸化価，沃素価の変化の状態を示した。

第 1 図にみられる如く，新鮮時に冷凍貯蔵したサケの酸価は，貯蔵開始後 40日頃まで徐々に増加するが，40日以後は大体一定の値を示している，然るに鮮度低下したサケを冷凍貯蔵した場合は，貯蔵開始後，約 100日を経過しても酸価は漸増加の傾向を示した，又，酸敗防止のため sustane 1-F を加えたサケは新鮮試料の場合と同様に，貯蔵の初期段階では酸価は稍々増加するが，貯蔵日数の経過に伴いその増加は抑制され 100日後でも 2.08 以上とはならなかつた，此の結果よりサケを低温度で貯蔵しても油脂の酸敗は徐々に進行し，特にこの傾向は貯蔵初期に著しいことがわかる，而かも，鮮度低下した試料では鮮度良好な試料と異なり酸敗の進行程度が激しい。酸価は遊離脂肪酸量を表わすものである故，貯蔵初期には之が増加するのが当然と思われるが，後期に至り増加しなかつたのは，里館[4]の報告した如く，一旦生じた遊離脂肪酸が重合するか他の物質と化合して斯様な現象を呈したと思われる。

第 2 図には新鮮試料並に sustane 1-F 添加試料は何れも同様な傾向を有することが認められる。即ち冷凍貯蔵後 40日頃までは減少し，酸価と逆の状態を示したが，貯蔵中期では増加し，更に貯蔵後期に至つて再び減少している，此のことは，サケを冷凍貯蔵中，初期段階では油脂が酸化分解したため脂肪酸総量は減少するが，冷凍期間が長期化すれば，酸化的分解が一旦停止し，再び脂肪酸の蓄積が始まり，更に長期間冷凍貯

Table 1. Changes in the specific numbers of salmon fats during cold storage

Sample		Days stored						
Fresh salmon in initial quality		0	15	38	50	65	82	108
	Acid value	1.23	1.85	2.4	2.6	2.3	2.5	2.6
	Saponification value	181.2	176.8	167.2	179.2	183.2	188.0	169.3
	Iodine value	142.2	121.7	114.1	101.8	107.2	103.5	81.9
Unfresh salmon in initial quality		0	27	40	65	80	100	
	Acid value	1.3	2.3	2.1	3.0	3.2	2.7	
	Saponification value	183.0	178.3	153.4	191.1	180.3	178.5	
	Iodine value	136.3	126.4	116.4	90.7	80.2	83.6	
Sustane 1-F added salmon		0	22	40	69	80	108	
	Acid value	1.6	2.2	1.9	1.6	2.1	2.1	
	Saponification value	183.0	189.0	178.4	185.6	177.2	168.1	
	Iodine value	142.4	145.0	140.8	136.9	111.3	107.9	

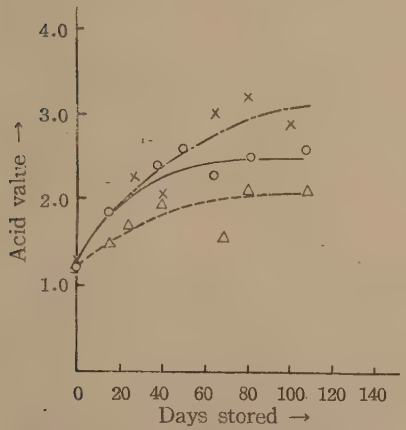

Fig. 1. Changes in the acid value of salmon fats during cold storage

—○— Fresh salmon in initial quality
--×-- Unfresh salmon in initial quality
--△-- Sustane 1-F added salmon

蔵すれば一旦蓄積された脂肪酸は自働酸化の如き分解過程を経て徐々に減少するものと思われる。然し此の事に関しては尚不明な点が多く，後日詳細に検討されなければならない。

第3図はサケ冷凍貯蔵中の沃素価の変化を示したが，何れの試料も経過日数に伴って漸次減少している。新鮮試料及び不鮮試料は略々同様な減少の傾向を有しているのに対し sustare 1-F 添加試料では比較的緩慢に減少する如く見受けられた。斯様に沃素価が冷凍貯蔵中減少を示したのは，酸価の増加と云う点を考慮して酸素吸収の現象を意味すると考えられる。

Lovern[7] によればサケ体油中の脂肪酸の種類は飽和脂肪酸としてはミリスチン酸（C_{14}），パルミチン酸（C_{16}），ステアリン酸（C_{18}）等であり，不飽和脂肪酸としてはゾーマリン酸（C_{16}），オレイン酸（C_{18}），ガドレイン酸（C_{20}），セトレイン酸（C_{22}）等でありその含有割合は不飽和度の高い脂肪酸の多いことが知られている。従つて冷凍貯蔵中に魚体中の脂肪が酸化し，酸化物及び過酸化物の生成が予想され，しかも本実験における油脂の特数の変化からも或る程度首肯されるが，此の点を明らかにするためエーテル抽出物量及び過酸化物量を測定したが，その結果は第2表，第4図及び第5図に示された如くである。

第4図は過酸化物酸素量の変化を示した。各試料共経過時間に伴って増加しているが，不鮮試料では最も多く過酸化物を生成し，新鮮試料並に sustane 1-F 添加試料は略々同程度に増加した。即ち油脂は漸次，酸化されるものと思われる。然し sustane 1-F 添加試料は貯蔵後期に減少の傾向を示しており，このことは酸価の変化で認められた如く，一旦生成した過酸化物が分解したことによると思われる。第5図はエーテル抽出物量

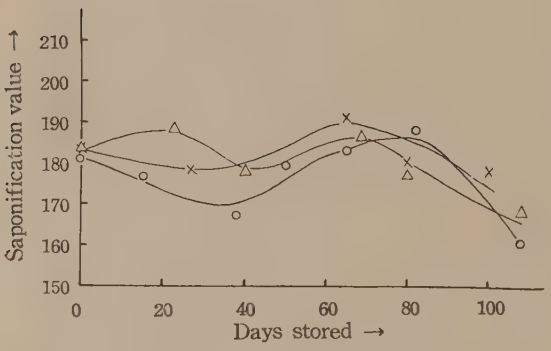

Fig. 2. Changes in the saponification value of salmon fats during cold storage

—○— Fresh salmon in initial quality
—×— Unfresh salmon in initial quality
—△— Sastane 1-F added salmon

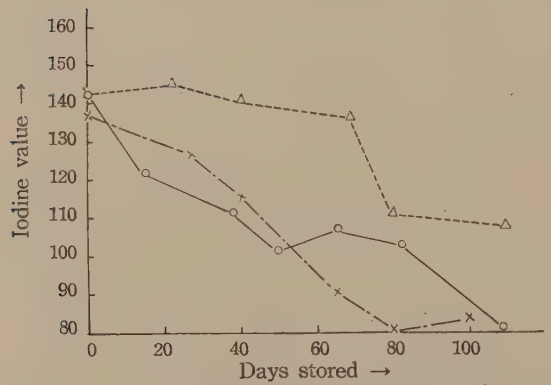

Fig. 3. Changes in the iodine value of salmon fats during cold storage

—○— Fresh salmon in initial quality
--×-- Unfresh salmon in initial quality
--△-- Sustane 1-F added salmon

の変化を示したが，新鮮試料では貯蔵開始後50日頃までは殆んど変化なく，後期に至り減少した。又 sustane 1-F 添加試料は70日頃迄は変化なく，以後減少している。かかる現象は沃素価の変化及び過酸化物酸素量の変化と同様に初期段階では空気中の酸素を吸収し後期では酸素吸収により生じた酸化物乃至は過酸化物が分解したため生起したものとも考えられる。

サケより抽出した油脂の性状は外山[7]が白サケより採油したものについての実験があるが，その結果と本実験結果を比較すれば第3表の如くである。其の他，広瀬[8]はサケ油の市販品は一般に沃素価が高く，140～160であり，鹸化価は180～190のものが多いと報告している。

第3表にみられる如く，著者等により得られた結果は，外山の報告とよく一致している。然し著者等の実験結果で，酸価が稍々小さい値を示したのは油脂の抽出時に waring blendor により抽出し，熱抽出を行わなかつたためと考えられる。

sustare 1-F による抗酸化効果は，既に多くの研究者により報告されているところであり，不飽和脂肪酸又はそのグリセライドに対して効果を有することが知られている。従つてサケの如く，高度不飽和酸に富む油脂に対して有効であると思われ，事実本実験結果においても sustane 1-F添加原料は無添加原料に比し，その酸化が抑制される如く見受けられた。而かも此の効果は貯蔵初期では充分に認められないが，貯蔵日数の経過に伴つて次第に明らかとなつている。此の事は Filer *et al.*[9], Lundberg *et al.*[10], Mahon & Chapman[11] 等の述べた如く，sustane 1-F が脂肪の過酸化物の活性化エネルギーの吸収，又は不飽和脂肪酸分子の連鎖反応を破断することによるものと考えられる。

以上の実験結果より明らかな如く，サケを−15°Cに冷凍貯蔵してもその脂肪分は緩徐ではあるが，化学的変化を受け変敗するものと思われる。斯様な変敗現象成立の素因としては，冷蔵庫内の水分及び酸素の存在が考えられ脂肪は加水分解により，グリセリン及び脂肪酸を生成し，此の中高級脂肪酸は更に分解して，低級脂肪酸，アルデヒド等を生じ，冷蔵庫臭の構成物質となると思われる。

Table 2. Changes in the amounts of peroxide-oxygen and ether extracts in frozen salmon

Sample		Days stored						
Fresh salmon in initial quality		0	15	38	50	65	82	108
	Peroxide-O_2	0.24	0.31	0.45	0.36	0.39	0.43	0.54
	Ether extract	7.24	7.69	7.25	7.15	6.25	6.58	6.20
Unfresh salmon in initial quality		0	26	40	65	80	100	
	Peroxide-O_2	0.25	0.3	0.48	0.63	0.77	0.80	
	Ether extract	7.58	10.41	6.75	7.38	6.75	6.35	
Sustane 1-F added salmon		0	22	40	69	80	108	
	Peroxide-O_2	0.24	0.29	0.34	0.43	0.50	0.48	
	Ether extract	7.40	7.03	7.36	7.51	6.83	7.00	

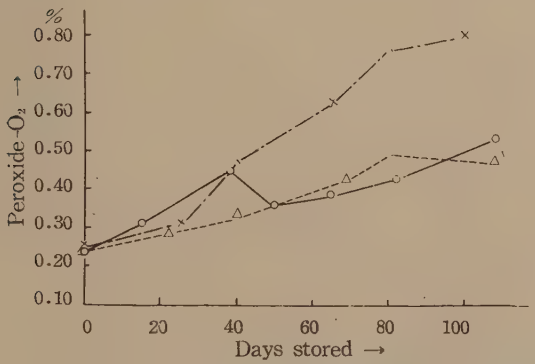

Fig. 4. Changes in the amounts of peroxide-oxygen from frozen salmon

—○— Fresh salmon in initial quality
--×-- Unfresh salmon in initial quality
--△-- Sustane 1-F added salmon

要　　約

サケの新鮮な原料，不鮮な原料及び sustane 1-F 添加原料を −15°C の冷蔵庫中に冷凍貯蔵した際の魚体脂肪の変化を測定した結果を要約すれば次の如くである。

(1) 酸価，鹸化価，沃素価，エーテル抽出物量，過酸化物酸素量の変化を綜合し，各原料は貯蔵初期段階では酸化するが，後期に至り酸化が抑制される。

(2) 酸化物及び過酸化物は冷凍期間を通じて増加する。然し貯蔵後期では，一旦生成された酸化物及び過酸化物は減少する。此の現象は分解乃至は重合により生起したものと解される。

(3) sustane 1-F を添加した試料は無添加試料に比し酸化が阻止される。此のことは，サケ体油中には不飽和脂肪酸が多いので，之に対して効果的であるためと考えられる。又 sustane 1-F は短期貯蔵原料に対しては効果が明らかでない。

(4) 不鮮な原料は新鮮原料に比し，冷凍貯蔵中容易に酸化され，これは鮮度低下により体油中に遊離脂肪酸が増加したためと考えられる。

(5) サケを冷凍貯蔵中，魚体脂肪は加水分解され，生じた高級脂肪酸は更に分解して低級脂肪酸，アルデヒド等を生じ，冷蔵庫臭の構成物質となると思われる。

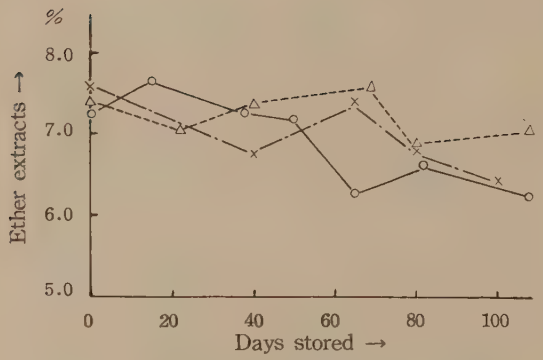

Fig. 5. Changes in the amounts of ether extracts from frozen salmon

—○— Fresh salmon in initial quality
--×-- Unfresh salmon in initial quality
--△-- Sustane 1-F added salmon

Table 3. Properties of the salmon fats

Sample No.	Acid value	Saponification value	Iodine value	Researcher
1	2.21	187.9	131.5	
2	4.11	188.9	128.3	Toyama
3	2.69	191.4	144.1	
4	1.23	181.2	142.2	Authours

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サケ罐詰の製造に関する研究

第4報　冷凍魚を原料としたサケ水煮罐詰の冷凍臭について

（4）　サケ冷凍貯蔵中の窒素量の変化

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Studies on the Manufacture of Canned Salmon

IV. The odor in canned salmon manufactured from frozen fish as the raw material

(4) Changes in the various types of nitrogen in salmon meat during cold storage

Eiichi TANIKAWA, Terushige MOTOHIRO and Shigeo SHOJI

Abstract

With the use of samples as detailed in the previous paper[1], changes in the various types of nitrogen in salmon during freezing storage were observed.

The results obtained are summarized as follows:

(1) The solubility of the meat protein of salmon by 0.2% NaOH solution has shown a tendency to increase with the lengthening of the freezing storage periods, therefore it was supposed to form of oxy-protein.

(2) Two types of nitrogen, volatile base and amino acid, have increased. This is considered to have been caused by such a change as autolysis or oxidative decomposition of salmon meat.

(3) The amount of total nitrogen appeared to decrease.

(4) It was assumed that the occurrence of amino-carbonyl reaction may have occurred from the results of examination of solubility, pH value and formation of fluorescence by irradiation of ultraviolet light. As the elements needed for this reaction, free amino gruoups and aldehydes may have been first encountered, while sugars in salmon have not played any important part.

(5) In fish with "Sustane 1-F" added, the meat proteins have changed as well as in materials not treated with "Sustane 1-F".

(6) With respect to the formation of the odor in canned salmon manufactured from frozen fish decomposition of meat protein in salmon showed less effect than did the decomposition of meat fats.

罐詰原料としてサケを冷凍貯蔵する際，その肉組成は化学的変化をうけ，所謂冷凍臭の構成臭気物質を生成すると考えられ，このため著者等[1]は前報においてサケの冷凍貯蔵中の脂肪の変化について報告した。

本研究ではサケの肉組成の主要構成分である，肉蛋白の変化，即ち肉焼け（meat burn）の現象について実験した結果を述べる。

従来，サケ肉の凍結貯蔵によつて生起する肉蛋白の変性は田所及び渡辺[2]により研究され，冷凍貯蔵により全窒素，食塩可溶性窒素は減少し，遊離アミノ酸態窒素は増加すると述べている。又，里館[3]は魚粉を常温で種々の条件下に貯蔵し，その蛋白の変敗現象を観察し，蛋白質も分子間の不飽和原子団と酸素とが結合し

酸化蛋白 (Oxy-protein) が生成すると考え，アルカリに対する溶解度を利用して，貯蔵中の酸化状態を研究している。

実　　験

試　料：

前報[1]と同様にして −15°C に冷凍貯蔵したサケ肉を実験に供した。

実験方法：

全窒素：磨細試料約1gを精秤し，ミクロケルダール法により全窒素量を定量した。

アミノ酸態窒素：Pope–Stevens の加銅法によつた。

揮発性塩基窒素：Weber & Wilson 法によつた。

冷水可溶性窒素：10倍浸出液を40分間攪拌した後，濾過して濾液 10cc 中の全窒素を測定した。

アルカリ可溶性窒素：0.2%苛性ソーダ溶液を用い，冷水可溶性窒素と同様に測定した。

結果及び考察

上記の方法により得られた結果を第1表，第2表，第1〜3図に示した。

Table 1. Changes in the solubility of the salmon meat caused by the alkali solution

Sample		Days stored						
Fresh salmon in initial quality		0	15	38	50	65	82	108
	Total–N	2.98	3.12	3.19	3.16	3.03	2.81	2.78
	Alkali soluble–N	0.47	0.42	1.15	1.84	1.84	1.69	1.67
	Solubility	15.77	13.46	36.05	58.23	61.39	60.14	60.07
Unfresh salmon in initial quality		0	27	40	65	80	100	
	Total–N	3.17	3.24	2.95	3.09	3.04	2.78	
	Alkali soluble–N	0.56	0.55	1.31	1.24	1.95	1.83	
	Solubility	17.67	16.98	44.41	40.13	64.14	65.82	
Sustane 1–F added salmon		0	22	40	69	80	108	
	Total–N	2.98	3.06	2.90	2.92	2.88	2.93	
	Alkali soluble–N	0.47	0.57	0.80	1.07	1.69	1.72	
	Solubility	15.77	18.63	28.97	36.64	58.67	58.70	

Solubility = alkali soluble–N /total–N ×100

第1表より明らかな如く，各試料共冷凍貯蔵を継続すれば，その全窒素量は僅かに減少する。之に対し，アルカリ可溶性窒素量は増加している。従つて第1図に見られるようにアルカリに対する溶解度は漸次増大する，即ち各試料共，冷凍貯蔵後20〜30日頃までは変化は認められないが，此の時期を経過すれば次第に変化し，この傾向は50〜80日頃まで継続し，後期では再び溶解度は一定となる。このことより冷凍貯蔵中に肉蛋白は酸化され，酸化蛋白の生成が認められる。然し酸化の程度は必ずしも各試料について同様でなく，又貯蔵期間を通じて，一定の割合で酸化されることもない。又新鮮試料と不鮮試料の変化は略々一致しているので肉蛋白の酸化は鮮度によつて著しく影響されることはないと思われる。sustane 1–F 添加原料は無添加原料と比較し，肉蛋白の酸化も或る程度抑制されるようであり貯蔵期間の全般に亘つて溶解度は低い値を示

した。

Table 2. Variations of some types of nitrogen in salmon meat during cold storage

Sample		Days stored						
Fresh salmon in initial quality		0	15	38	50	65	82	108
	NH_3-N(mg%)	5.0	5.5	10.1	13.8	15.3	14.4	19.2
	NH_2-N(mg%)	23.6	23.6	25.1	25.1	22.3	25.1	27.6
	Water soluble -N(%)	0.11	0.18	0.35	0.51	0.46	0.39	0.33
Unfresh salmon in initial quality		0	27	40	65	80	100	
	NH_3-N(mg%)	17.0	17.8	23.0	26.8	30.0	33.4	
	NH_2-N(mg%)	25.4	23.8	26.7	26.7	29.2	29.2	
	Water soluble -N(%)	0.23	0.38	0.37	0.64	0.56	0.40	
Sustane 1-F added salmon		0	22	40	69	80	108	
	NH_3-N(mg%)	5.0	12.3	10.0	11.7	10.8	12.5	
	NH_2-N(mg%)	23.6	23.6	24.4	22.5	25.3	27.4	
	Water soluble -N(%)	0.11	0.20	0.28	0.49	0.40	0.38	

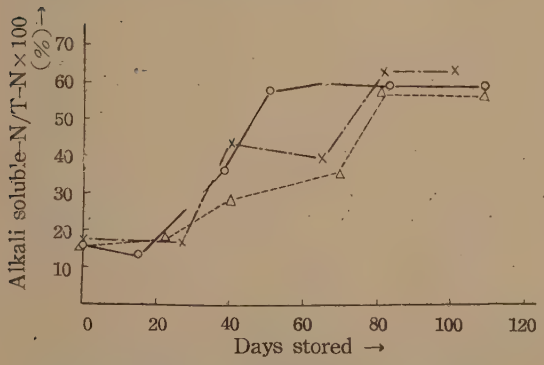

Fig. 1. Changes in the solubility of the salmon meat caused by the alkali solution

—○— Fresh salmon in initial quality
--×-- Unfresh salmon in initial quality
--△-- Sustane 1-F added salmon

第1表において，各試料共に全窒素量が日数の経過に伴い，僅かではあるが減少しているのは揮発性物質等の生成により窒素が失われたためと考えられる。此の結果は田所及び渡辺[2]等の実験結果と一致している。

第2図はサケ冷凍貯蔵中の揮発性塩基窒素量の変化を示したが，此の結果より冷凍貯蔵中でも揮発性塩基窒素量は明らかに増加することが認められる。即ちサケ肉質は化学的変化により分解され，低分子の塩基を生成するものと思われ，前報[1]で述べた如く，サケを収容した冷蔵室より検出されたカダベリン，ピペリジンの如き塩基はその母体が冷蔵庫内のサケにあることを或る程度説明し得ると考えられる。試料別にみて，鮮度低下したサケは冷凍貯蔵中多量の揮発性塩基を生じ，一方鮮度良好なサケは，少量の揮発性塩基を生ずるのは当然のことと思われる。然しその増加量の程度は，両試料共大体同様である。換言すれば揮発性塩基窒素は，鮮度とは無関係に増加するものの如く思われる。又，sustane 1-F 添加によりサケ肉蛋白の酸化的に分解されるのが抑制されたことにもよるものであろう。

第2表にみられる如く，アミノ態窒素は不定な値を示したが，概して増加しているようであり，之は冷凍貯蔵中に肉蛋白が，緩慢な自家消化により分解されたものと思われる。

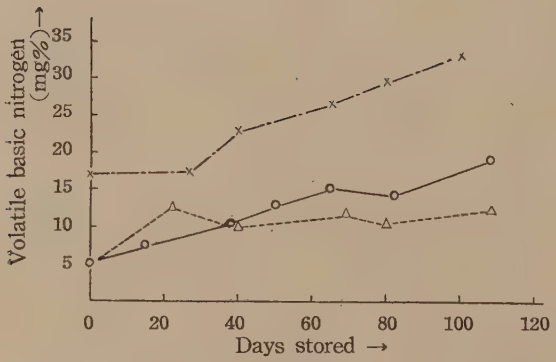

Fig. 2. Changes in the amounts of volatile basic nitrogen in salmon meat during cold storage

—○— Fresh salmon in initial quality
--×-- Unfresh salmon in initial quality
--△-- Sustane 1-F added salmon

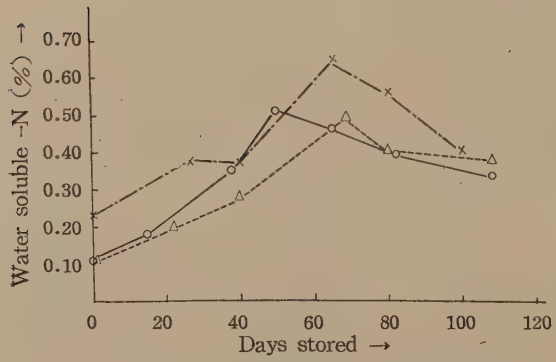

Fig. 3. Changes in the amounts of water soluble nitrogen in salmon meat during cold storage

—○— Fresh salmon in initial quality
--×-- Unfresh salmon in initial quality
--△-- Sustane 1-F added salmon

第3図は水溶性窒素量の変化を示した。此の結果によれば，各試料共に溶出窒素量は一旦増加するが，後期に至り減少している。即ち新鮮原料では50日目，不鮮原料並に sustane 1-F 添加原料は65日，又は70日日頃を境界として逆の傾向を示した。一般に冷凍貯蔵中可溶性窒素は増加すると考えられるので初期段階で増加することは首肯されるが，貯蔵後期に於ける減少は肉蛋白の分解とゆうことでは説明し得ない。而して，この点については，アミノ・カルボニール反応の生起を予想することにより極めて良く説明し得られる。元来，アミノ・カルボニール反応は主として，乾燥野菜，乾燥卵，粉乳，煉乳を貯蔵する際生ずる褐色化の原因を究明する場合に問題とされていたが Tarr[4] は水産食品にあつてもかかる反応が成立することを実証している。しかも此の反応は単に食品の褐色化反応のみを表わすのみでなく，食品貯蔵時における風味の低下，異臭の発生をも促進すると云われる。此の反応は上記の褐色化の外に溶解度の減少，pH 価の低下，紫外線照射による螢光の発生とゆう現象を伴つている。それ故第4図に示される如く pH 価の変化を可溶性窒素量の増減と比較するに pH 価も冷凍貯蔵後，一旦上昇するが，可溶性窒素量が減少する時期に至り低下し，結局 pH 価と可溶性窒素量とは同様な傾向を有することが認められた。更に各試料に対して紫外線照射を行つたところ，冷凍貯蔵の初期段階では螢光は全く認められず，貯蔵開始後70日間を経過した頃より腹肉，血合肉附近に螢光が認められ，この程度は貯蔵日数が延引するに従つて顕著となつた。田所・渡辺[2] が行つたサケの凍結貯蔵中の肉成分の変化についての実験では，モノアミノ態窒素は増加し，ヂアミノ酸は減少する。特にヒスチヂン，アルギニンは減少すると述べている。又 Hannan & Lea[5] はカゼインと葡萄糖のモデル実験を行い，アミノ・カルボニール反応が行われる際，ヘキソン・ベース，就中リジン，アルギニンの減少が顕著であり，之はカルボニール基が α 位のアミノ基以外のアミノ基と結合することを意味すると述べている。之等の諸現象を綜合して考察するに，冷凍貯蔵中にアミノ・カルボニール反応が生起する可能性が充分あるものと考えられる。

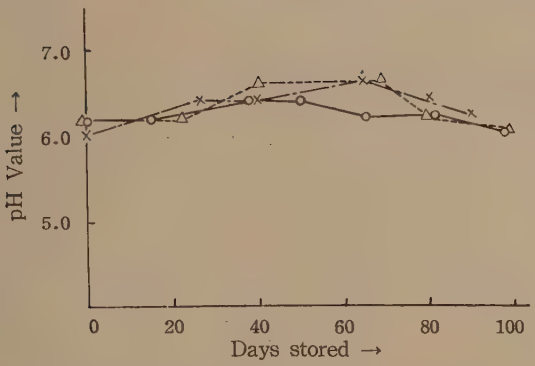

Fig. 4. Changes in the pH value in salmon meat during cold storage

—○— Fresh salmon in initial quality
--×-- Unfresh salmon in initial quality
--△-- Sastane 1-F added salmon

アミノ・カルボニール反応の成立にはアミノ基及びカルボニール基の存在が必要とされるが，冷凍貯蔵時には前記の如く，自家消化，酸化的分解等により遊離状態の窒素化合物が生成し，之等化合物が先に報告した如く冷蔵庫内のアルデヒド類，例えばフオルムアルデヒド乃至はアセトアルデヒド等と結合する素地が考慮される。Tarr[4] の報告によればサケ肉に含有されるリボース量は僅かであるので，アミノ・カルボニール反応は顕著に生起しないと述べている。従つて肉組成中の反応因子として糖類は重視されない。サケはタラ，カレイ等の白身の魚と異なり，その肉色は赤色である故，アミノ・カルボニー反応が生起しても概して看過されるのではないかと思われる。何れにせよ，本実験の結果では充分にアミノ・カルボニール反応の生成が予想されるが，此の点については今後詳細な研究を行わなければならない。

以上の結果より冷凍貯蔵中に各種窒素量は徐々に変化し，自家消化又は酸化的分解により酸化蛋白の生成，揮発性塩基の増加，アミノ酸の増加が認められた。然し乍ら，之等の変化は極めて僅かであつて，官能的にも肉組成の変化は顕著に認められず，前報で報告した如き魚体脂肪の酸化，加水分解に比し，遙かに劣るように見受けられる。それ故，冷蔵庫臭が肉組成分の分解生産物に由来するとするならば，蛋白組成以上に脂肪の方が重要な役割を演ずるものと考えられる。

要　　約

サケの新鮮な原料，不鮮原料及び sustane 1-F 添加原料を −15°C の冷蔵庫中に冷凍貯蔵し，その窒素量の変化を測定した結果を要約すれば，次の如くである。

（1）0.2%苛性ソーダに対する溶解度は経過日数に伴つて漸増し，酸化蛋白の生成が認められた。

（2）揮発性塩基窒素量，アミノ態窒素量は漸増する如くであり，之は蛋白質が自家消化又は酸化的分解により変化したものと考えられる。

（3）溶解度，pH 価，紫外線照射による螢光の発生により，アミノ・カルボニール反応の生起が予想された。而して此の反応の成立素因としては，遊離アミノ酸及びアルデヒド類が考えられる。

（4）sustane 1-F 添加試料も無添加試料と同様に，その蛋白質は変化する。

（5）サケ肉蛋白の分解は，冷凍臭の生成に関しては脂肪分解ほど甚だしくはない。

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サケ罐詰の製造に関する研究

第5報　冷凍魚を原料としたサケ水煮罐詰の冷凍臭について

(5)　サケ冷凍貯蔵中の揮発性物質の消長

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Studies on the Manufacture of Canned Salmon

V. The odor in canned salmon manufactured from frozen fish as the raw material

(5) Changes in the volatile compounds in salmon meat during cold storage

Eiichi TANIKAWA, Terushige MOTOHIRO and Shigeo SHOJI

Abstract

With the same samples as described in the previous paper[2], changes in the volatile compounds in salmon meat during cold storage have been observed by means of paper chromatography.

The results obtained are summarized as follows:

(1) Many compounds of volatile bases and acids have appeared steadily throughout the cold storage period. This tendency is the most remarkable in the sample which was unfresh in its initial quality, and less in the sample treated with "Sustane 1-F". This indicates that the addition of "Sustane 1-F" to fish prevents a decomposition of meat tissue.

(2) In the sample which was fresh in initial quality, the components of volatile base were cadaverine and piperidine, while in the sample which was unfresh in initial quality, cadaverine, piperidine, agmatine, amylamine have been recognized. Therefore, considering from the results obtained in earlier works of this series, a part of the particular odor in the refrigerated warehouse which is loaded with salmon, would be caused by the decomposition products of salmon meat protein.

(3) As components of volatile acids, only formic acid was detected in the earlier part of storing period. In a later stage of the storing period, higher fatty acids than formic acid have appeared successively.

(4) If the cold storage should be prolonged, great quantities of volatile compounds would be formed. Therefore the storage of salmon in freezing chamber for more than 50 days and the use of salmon which was not fresh in initial quality, must be avoided if it is desired to manufacture a good canned product.

著者等は先に冷凍サケを収容した冷蔵室内の空気中の臭気を検索しピペリジン，カダベリン，トリメチルアミン，蟻酸，δ-アミノバレルアルデヒド，アセトアルデヒド，フオルムアルデヒド，メルカプタン様昜臭物質，アムモニア，エチレン，硫化水素，燐化水素を認知し[1]，更に之等の物質の中塩基，酸及びアルデヒード類はサケ肉を冷凍貯蔵した際，成分脂肪又は蛋白の化学変化により産生されるものと想定した[2]。

本報ではサケ冷凍貯蔵中における之等揮発性物質の中，揮発性塩基及び揮発酸の消長について報告する。

実　　　験

試　料：

前報[2]と同様にして −15°C に冷凍貯蔵したサケ肉及び冷凍前に sustane 1-F を以て処理したサケ肉を実験に供した。

実験方法：

揮発性塩基　磨細したサケ肉 50g を蒸溜用フラスコに取り，10％苛性ソーダを注加して，水蒸気蒸溜する。受器には1 N塩酸 2 cc を入れ冷却器の先端を塩酸溶液中に浸す。40分間水蒸気蒸溜した後，溜液を湯浴上で濃縮し，殆んど乾固せしめる。之に蒸溜水を加えて約1 ccとなし前報の如く，一次元上昇法により，ペーパー・クロマトグラフ法を行い，ニンヒドリンで顕色した。

揮発性脂肪酸　Fink[3]等の方法により揮発酸をエステル化し，之をヒドロオキザム酸カリとした後，濾紙クロマトグラフにより分離検出した。濾紙クロマトグラフの実験条件は前報[2]に記した。

結果及び考察

上記の方法によって実験し，得られた結果は次の如くである。即ち第1報には揮発性塩基窒素量及び揮発酸量の変化を総括したが，此の中揮発性塩基量の変化は既に示してある[1]故，揮発酸量の変化を図示すれば第1図の如くなる。

Table 1. Changes in the amounts of volatile basic nitrogen and volatile acids in salmon meat during cold storage

Sample		Days stored						
Fresh salmon in initial quality		0	15	38	50	65	82	105
	NH_3-N(mg%)	5.0	5.5	10.1	13.8	15.3	14.4	19.2
	Volatile acid (mg%)	0.3	0.4	0.6	0.7	1.7	1.7	2.8
Unfresh salmon in initial quality		0	27	40	65	80	100	
	NH_3-N(mg%)	17.0	17.8	23.0	26.8	30.0	33.4	
	Volatile acid (mg%)	0.1	0.8	1.4	1.7	2.5	3.1	
Sustane 1-F added salmon		0	22	40	69	80	108	
	NH_3-N(mg%)	5.0	12.3	10.0	11.7	10.8	12.5	
	Volatile acid (mg%)	0.3	0.8	0.8	1.3	1.5	2.6	

又，第2表にはペーパー・クロマトグラフ法により検出された揮発性塩基並びに揮発酸組成を示したが，之を図示すれば第2図及び第3図の如くである。

第1表及び第1図に示された結果をみると，各試料共に貯蔵日数が増加すれば揮発酸量は増加している。これは既に多くの研究者によっても報告されているが，肉組成中の高級脂肪酸の低次化，若くはアミノ酸の[illegible]と考えられる。一方，揮発酸組成の増加量を試料別に考察すれば，不鮮試料は[illegible]，これは上記の理由により理解し得られる。sustane 1-F 添加試料は新鮮[illegible]，然し貯蔵中[illegible]では Mahon & Chapman[4] により報告され

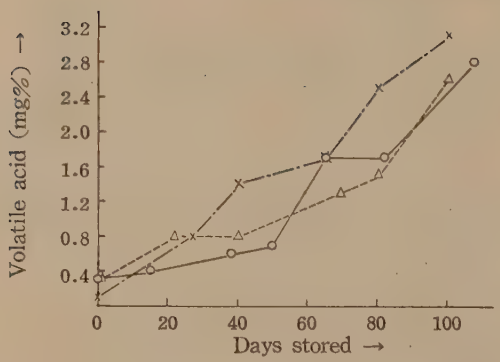

Fig. 1. Changes in the amounts of volatile acids

—○— Fresh salmon in initial quality
--×-- Unfresh salmon in initial quality
--△-- Sustane 1-F added salmon

ている如く，肉組成の分解は或る程度抑制され，その増加量も少ない。

之等の結果は第3図に示された揮発酸組成の消長によつても明らかに知られる。即ち各試料の間では鮮度が低下していれば揮発酸組成は比較的初期の段階より検出され，而かもその組成は単一なものから次第に複雑となる。此の事は Hillig & Clark[7] の結果と一致している。又 sustane 1-F 添加試料では，その肉組成の分解が阻害されると考えられるが，これは揮発酸組成の検出される時期が新鮮試料の場合と比較して可成り遅れていることによつても判る。

第2図は揮発性塩基組成の消長を示したが，その消長は揮発酸組成の場合と同様な傾向を有し，不鮮試料は新鮮試料と比較してその揮発性塩基組成は冷凍貯蔵中，初期

Table 2. Components of volatile bases and acids, detected by paper chromatography

Sample		Days stored						
Fresh salmon in initial quality		0	15	38	50	65	82	108
	Volatile base	none	none	none	none	Cadaverine	〃	〃
	Volatile acid	none	none	none	none	Formic acid	〃	〃
Unfresh salmon in initial quality		0	27	40	65	80	100	
	Volatile base	Cadaverine	〃	〃 Piperidine	〃	〃 Agmatine	〃 Amylamine	
	Volatile acid	none	none	Formic acid	〃	〃 Acetic acid	〃 Propionic acid	
Sustane 1-F added salmon		0	22	40	69	80	108	
	Volatile base	none	none	none	none	none	Cadaverine	
	Volatile acid	none	none	none	none	none	Formic acid	

の段階より出現し，経過日数の増加に伴つて多種類に亘り検出された。sustane 1-F 添加試料の揮発性塩基組成の消長も無添加試料と比較して，極めて簡単であつて，肉組成の分解が阻止されることが伺われる。

著者等は既に，サケを収容した冷蔵室の臭気を検索し，揮発性塩基としてカダベリン，ピペリジン，トリメチルアミンを検出したが，本実験では此の中，カダベリン，ピペリジンを認めた外，鮮度低下したサケよ

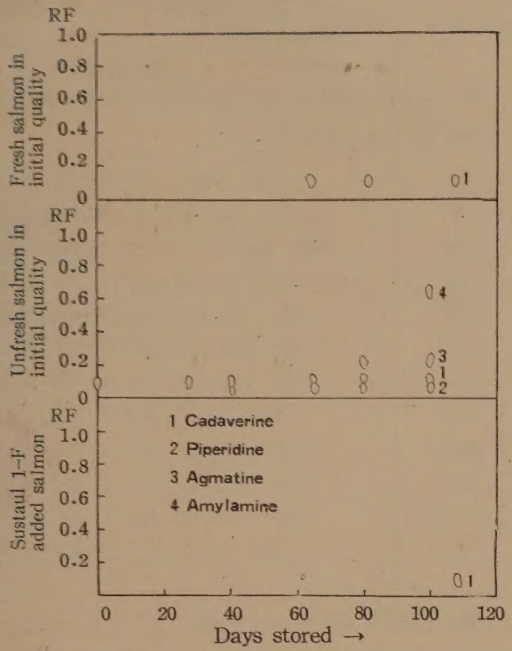

Fig. 2. Variations of the components of volatile bases in salmon meat during cold storage

りアグマチン，アミルアミンを検出した。従つて，サケを収容した冷蔵室の臭気は，その一部はサケ肉に由来すると考えられる。更に新鮮肉及び sustane 1-F 添加試料からはカダベリンを認めたのみであつて，ピペリジン，アグマチン，アミルアミンは検出されなかつた。それ故，前報における冷蔵庫内のサケには鮮度の低下した魚体もあつたものと思われる。然しアグマチン，アミルアミンは凍結貯蔵期間が可成り長期間とならなければ検出されず，且つ鮮度低下したサケのみより検出されている故，上記の冷蔵庫内のサケは余り長期間冷凍貯蔵したものでないことが判る。揮発酸組成にあつてもサケを収容した冷蔵室から昇臭成分として蟻酸が分離されており，この物質は各試料共に貯蔵後日数を経てから検出されているので，肉組成分の分解後に生成し，之が冷蔵室内に揮発して昇臭成分となつたものと思われる。

上記の如く，サケの肉組成中より検出された揮発性塩基組成及び揮発酸組成は罐詰製造時にそのまま罐内に移入されるものであるか否かは未明であり，例えば冷凍原料より巻締に至るまでには調理，水洗等の操作を経ているので，之等組成分の流去乃至は逸散が考えられる。而かも反対に，罐詰内では殺菌時に揮発酸及び揮発性塩基量が増加するので，夫等の組成分の種類も増加するのではないかとも考えられる。

何れにせよ各試料共に冷凍貯蔵日数が長期化すれば，夫等の揮発性塩基及び揮発酸はその種類も量も共に増加し，又鮮度が低下した試料では此の傾向が一層顕著となる故，罐詰原料としてのサケは長期間（50日間以上貯蔵すること，及び不鮮原料の使用は避けるべきである。

要　約

前報に記したと同様な試料を用い，サケを冷凍貯蔵した際生ずる揮発性塩基，揮発酸組成の消長をペーパー・クロマトグラフ法により検索した結果を要約すれば次の如くである。

(1) 揮発性塩基及び酸の組成は冷凍貯蔵の期間を通じて漸次多種類となつて来る。而かも此の傾向は不鮮原料において最も著しく，sustane 1-F 添加試料では著しい変化はない。従つて sustane 1-F 添加により，サケ肉組成分の分解が抑制されていることが判つた。

(2) 揮発性塩基組成は最初の鮮度が良好であつた試料では，カダベリン，ピペリジンが認められた。最初の鮮度が低下していた試料では，カダベリン，ピペリジン，アミルアミンを検出した。それ故，前報の結果と併考して，サケを収容した冷蔵庫の臭気はその一部はサケ肉に由来することが判つた。

(3) 揮発酸組成としては蟻酸がサケの冷凍貯蔵中最初に出現し，以後経過日数に伴つて次第に高次化することが認められた。

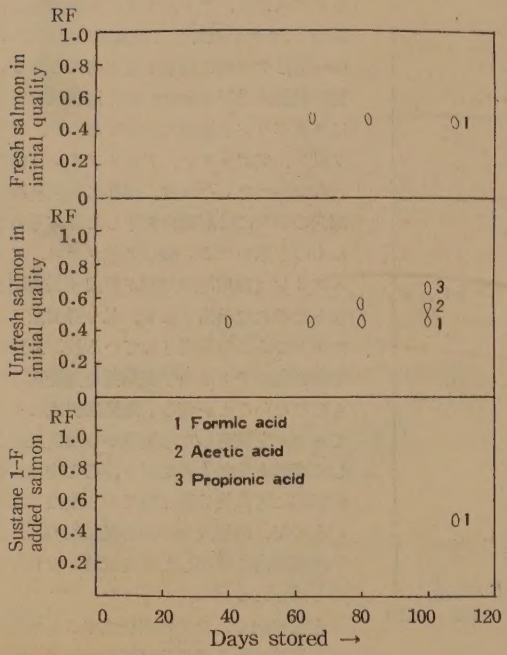

Fig. 3. Variations of the components of volatile acids in salmon meat during cold storage

(4) 長期間冷凍貯蔵すれば，揮発性物質は多種且つ多量に亘つて生成する故，罐詰原料としてのサケは長期間貯蔵すること（50日以上，）及び不鮮原料の使用は避けるべきである。

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